REPORT

OF THE

Nineteenth Annual Meeting

OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE ADVANCEMENT OF SCIENCE,

Being Volume XVIII of the South African Journal of Science.

DURBAN

1921.

JULY 11—16.

JOHANNESBURG:
PUBLISHED BY THE ASSOCIATION.

1922.

CONTENTS.

Papers Read and Published—*continued.*

LIST OF PLATES.

NATAL WITNESS, LTD., MARITZBURG.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

(1921, DURBAN.)

Vol. XVIII. DECEMBER, 1921. Nos. 1 and 2.

CONSTITUTION

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

[*As amended at the Nineteenth Annual Meeting at Durban,* 1921.]

I.—OBJECTS.

The objects of the Association are:—To give a stronger impulse and a more systematic direction to scientific enquiry; to promote the intercourse of societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

II.—MEMBERSHIP.

(*a*) All persons interested in the objects of the Association are eligible for Membership.

(*b*) Institutions, Societies, Government Departments and Public Bodies are eligible as "Institutional Members."

(*c*) The Association shall consist of (a) Life Members, (b) Ordinary Members (both of whom shall be included under the term "Members"), (c) Institutional Members, and (d) Temporary Members, elected for a session, hereinafter called "Associates."

(*d*) Members, Institutional Members and Associates shall be elected directly by the Council, but Associates may also be elected by Local Committees. Members may also be elected by a majority of the Members of Council resident in that centre at which the next ensuing session is to be held.

(*e*) The Council shall have the power, by a two-thirds vote, to remove the name of a Member of any class whose Membership is no longer desirable in the interests of the Association.

III.—PRIVILEGES OF MEMBERS AND ASSOCIATES.

(*a*) Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association.

(*b*) Ordinary Members shall be eligible for all offices of the Association and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay, *without intermission*, their Annual Subscription.

(*c*) Institutional Members shall receive *gratuitously* all ordinary publications of the Association on the same conditions as ordinary members; and each Institutional Member shall be entitled to send one representative to the Annual Session of the Association.

(*d*) Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association.

(*e*) Members and Institutional Members may purchase from the Association (for the purpose of completing their sets) any of the Annual Reports of the Association, at a price to be fixed upon by the Council.

IV.—SUBSCRIPTIONS.

(*a*) Every Life Member shall pay, on admission as such, the sum of Fifteen Pounds.

(*b*) Ordinary and Institutional Members shall pay, on election, an Annual Subscription of One Pound Ten Shillings. Subsequent Annual Subscriptions shall be payable on the first day of July in each year.

(*c*) An Ordinary Member may at any time become a Life Member by one payment of Fifteen Pounds in lieu of future Annual Subscriptions. An Ordinary Member may, after ten years, provided that his subscriptions have been paid regularly without intermission, become a Life Member by one payment of Seven Pounds Ten Shillings in lieu of future Annual Subscriptions.

(*d*) The Subscription for Associates for a Sesson shall be One Pound.

V.—MEETINGS.

The Association shall meet in Session annually. The place of meeting shall be appointed by the Council as far in advance as possible, and the arrangements for it shall be entrusted to the Local Committee, in conjunction with the Council.

VI.—COUNCIL.

(*a*) The Management of the affairs of the Association shall be entrusted to a Council, five to form a quorum.

(*b*) The Council shall consist of the President, Retiring President, four Vice-Presidents, two General Secretaries, General Treasurer, the Editor of the publications of the Association, and the Librarian, together with one Member of Council for every twenty Members of the Association.

(*c*) The President, Vice-Presidents, General Secretaries, General Treasurer, the Editor of the publications of the Association and the Librarian shall be nominated at a meeting of Council not later than two months previous to the Annual Session, and shall be elected at the Annual General Meeting.

(*d*) Ordinary Members of Council to represent centres having more than twenty Members shall, not later than one month prior to the Annual Session of the Association, be elected by each such Centre, in the proportion of one representative for every twenty Members. The Annual General Meeting shall elect other Ordinary Members of Council, in number so as to give, together with the Members of Council already elected by the Centres, in all, one Member of Council for every twenty Members of the Association.

(*e*) The Council shall have the power to co-opt Members, not exceeding five in number, from among the Members of the Association resident in that Centre at which the next ensuing Session is to be held.

(*f*) In the event of a vacancy occurring in the Council, or among the Officers of the Association, in the intervals between the Annual

Sessions, or in the event of the Annual Meeting leaving vacancies, the Council shall have the power to fill such vacancies.

(*g*) During any Session of the Association the Council shall meet at least twice, and the Council shall meet at least six times during the year, in addition to such meetings as may be necessary during the Annual Session of the Association.

(*h*) The Council shall have the power to pay for the services of Assistant General Secretaries for such clerical assistance as it may consider necessary, and for such assistance as may be needed for the publication of the Association Report or Journal.

(*i*) The Council shall have power to frame Bye-laws to facilitate the practical working of the Association, so long as these Bye-laws are not at variance with the Constitution.

VII.—LOCAL AND RECEPTION COMMITTEES.

(*a*) A Local Committee shall be constituted for the Centre at which the Annual Session is to be held, and shall consist of the Members of the Council resident in that Centre, with such other Members of the Association as the said Members of Council may elect.

(*b*) The Local Committee shall form a Reception Committee to assist in making arrangements for the reception and entertainment of visitors. Such Reception Committee may include persons not necessarily Members or Associates of the Association.*

(*c*) The Local Committee shall be responsible for all expenses in connection with the Annual Session of the Association.

VIII.—HEADQUARTERS.

The Headquarters of the Association shall be in Johannesburg.

IX.—FINANCE.

(*a*) The Financial Year shall end on the 31st of May.

(*b*) All sums received for Life Subscriptions and for Entrance Fees shall be invested in the names of three Trustees appointed by the Council, and only the interest arising from such investment shall be applied to the uses of the Association, except by resolution of a General Meeting; provided that any composition fee as a Life Member paid over to the Trustees of the Endowment Fund after the 30th day of May, 1914, may, upon the death of such Member, be repaid by the Trustees to the General Account of the Association, if the Council shall so decide.

(*c*) The Local Committee of the Centre in which the next ensuing Session is to be held shall have the power to expend money collected, or otherwise obtained in that Centre, other than the subscriptions of Members. Such disbursements shall be audited, and the financial statement and the surplus funds forwarded to the General Treasurer within one month after the Annual Session.

(*d*) All cheques shall be signed by the General Treasurer and a General Secretary, or by such other person or persons as may be authorised by the Council.

(*e*) Whenever the balance in the hands of the Treasurer shall exceed the sum requisite for the probable or current expenses of the Association, the Council shall invest the excess in the names of the Trustees.

(*f*) On the request of the majority of the Members of Council of any Centre in which two or more Members of Council reside, the

---

* The Reception Committee should make arrangements to provide:—

(1) A large hall for the delivery of the Presidential Address and evening lectures.

(2) A large room to be used as a Reception Room for members and others, at which all information regarding the Association can be obtained, and which shall have attached to it two Secretaries' Offices, a Writing Room for members and others, a Smoking Room, and Ladies' Room.

(3) Six rooms, each capable of accommodating about 30 or 40 people, to be used as Sectional Meeting Rooms, and, if possible, to have rooms attached, or in close proximity, for the purpose of holding meetings of Sectional Committees.

(4) Other requirements, such as office furniture, blackboards, window blinds to darken sectional meeting rooms for Lantern lectures, notice boards, etc.

Council shall empower the local Members of Council in that Centre to expend sums not exceeding in the aggregate 10 per centum of the amount of Annual Subscriptions raised in that Centre.

(*g*) The whole of the accounts of the Association, *i.e.*, the local as well as the general accounts, shall be audited annually by an auditor appointed by the Council, and the balance-sheet shall be submitted to the Council at the first meeting thereafter, and be printed in the Annual Report of the Association.

X.—SECTIONS OF THE ASSOCIATION.

The Scientific Work of the Association shall be transacted under such sections as shall be constituted from time to time by the Council, and the constitution of such Sections shall be published in the Journal.

The Sections shall deal with the following Sciences and such others as the Council may add thereto from time to time:—Agriculture; Anthropology and Ethnology; Archæology; Architecture; Anatomy; Astronomy; Bacteriology; Botany; Chemistry; Education; Engineering; Eugenics; Geodesy and Surveying; Geography; Geology and Mineralogy; Irrigation; Mathematics; Mental Science; Meteorology; Philology; Physics; Physiology; Political Economy; Sanitary Science; Sociology; Statistics; Zoology.

XI.—RESEARCH COMMITTEES.

(*a*) Grants may be made by the Association to Committees or to individuals for the promotion of Scientific research.

(*b*) Every proposal for special research, or for a grant of money in aid of special research shall primarily be considered by the Sectional Committee dealing with the science specially concerned, and if such proposal be approved, shall be referred to the Council.

(*c*) A Sectional Committee may recommend to Council the appointment of a Research Committee, composed of Members of the Association, to conduct research or to administer a grant in aid of research.

(*d*) In recommending the appointment of Research Committees, the Sectional Committee shall specifically name all Members of such Committees; and one of them, who has notified his willingness to accept the office, shall be appointed to act as Secretary. The number of Members appointed to serve on a Research Committee shall be as small as is consistent with its efficient working.

(*e*) All recommendations adopted by Sectional Committees shall be forwarded without delay to the Council for consideration and decision.

(*f*) Research Committees shall be appointed for one year only, but if the work of a Research Committee cannot be completed in that year, application may be made, through a Sectional Committee, at the next Annual Session for re-appointment, with or without a grant—or a further grant—of money.

(*g*) Every Research Committee, and every individual, to whom a grant had been made, shall present to the following Annual Meeting a report of the progress which has been made, together with a statement of the sums which have been expended. Any balance shall be returned to the General Treasurer.

(*h*) In each Research Committee, the Secretary thereof shall be the only person entitled to call on the Treasurer for such portions of the sums granted as may from time to time be required.

XII.—SPECIAL COMMITTEES.

The Council shall have power to appoint Special Committees to deal with such subjects as it may approve, to draft regulations for any such Committees, and to vote money to assist the Committees in their work.

XIII.—SECTIONAL COMMITTEES.

(*a*) The Sectional Committees shall consist of a President, two Vice-Presidents, two or more Secretaries, and such other persons as the

Council may consider necessary, who shall be elected by the Council. Of the Secretaries, one shall act as Recorder of the Section, and at least one shall be resident in the Centre where the Annual Session is to be held.

(*b*) From the time of their election, which shall take place as soon as possible after the Session of the Association, they shall form themselves into an organising Committee for the purpose of obtaining information upon Papers likely to be submitted to the Sections, and for the general furtherance of the work of the Sectional Committees.

(*c*) The Sectional Committees shall have power to add to their number from among the Members of the Association.

(*d*) The Committees of the several Sections shall determine the acceptance of Papers before the beginning of the Session, keeping the General Secretaries informed from time to time of their work. It is therefore desirable in order to give an opportunity to the Committees of doing justice to the several communications, that each author should prepare an Abstract of his Paper, and he should send it, together with the original Paper, to the Secretary of the Section before which it is to be read, so that it may reach him at least a fortnight before the Session.

(*e*) Members may communicate to the Sections the Papers of non-members.

(*f*) The Author of any Paper is at liberty to reserve his right of property therein.

(*g*) The Sectional Committees shall meet not later than the first day of the Session in the Rooms of their respective Sections, and prepare the programme for their Sections and forward the same to the General Secretaries for publication.

(*h*) The Council cannot guarantee the insertion of any Report, Paper or Abstract in the Annual Volume unless it be handed to the Secretary of the Section before the conclusion of the Session.

(*i*) The Sectional Committees shall report to the Council what Reports, Papers or Abstracts it is thought advisable to print, but the final decision shall rest with the Council.

XIV.—ALTERATION TO RULES.

Any proposed alteration of the Rules—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council and communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

During the interval between two Annual Sessions of the Association, any alterations proposed to be made in the Rules shall be valid if agreed to by two-thirds of the Members of Council. Such alteration of Rules shall not be permanently incorporated in the Constitution until approved by the next Annual Meeting.

XV.—VOTING.

In voting for Members of Council, or on questions connected with Alterations to Rules, absent Members may record their vote in writing.

RULES FOR THE AWARD OF MEDALS.

A.—The South Africa Medal.

I.—Constitution of Committee.

(*a*) The Council of the South African Association for the Advancement of Science shall, annually and within three months after the close of the Annual Session, elect a Committee to be called "the South Africa Medal Committee," on which, as far as possible, every Section

of the Association and each Province of South Africa shall have fair representation.

(*b*) This Committee shall consist of eight Members elected from amongst Council Members, together with four other Members, selected from amongst Members of the Association who are not on the Council.

(*c*) Each new Committee shall retain not less than four members who have served on the previous Committee.

(*d*) The Chairman of the Committee shall be appointed annually by the Council from amongst its Members.

(*e*) Any casual vacancy in the Committee shall be filled by the Council.

II.—DUTIES.

(*a*) The duties of the Committee shall be to administer the Income of the Fund and to award the Medal, raised in commemoration of the visit of the British Association to South Africa in 1905, in accordance with the resolution of its Council.

(*b*) This resolution read as follows:

(1) That, in accordance with the wishes of subscribers, the South Africa Medal Fund be invested in the names of the Trustees appointed by the South African Association for the Advancement of Science.

(2) That the Dies for the Medal be transferred to the Association to which, in its corporate capacity, the administration of the Fund and the award of the Medal shall be, and is hereby, entrusted, under the conditions specified in the Report to the Medal Committee.

(*c*) The terms of conveyance are as follows:—

(1) That the Fund be devoted to the preparation of a Die for a Medal, to be struck in Bronze, 2½ inches in diameter; and that the balance be invested and the annual income held in trust.

(2) That the Medal and income of the Fund be awarded by the South African Association for the Advancement of Science for achievement and promise in scientific research in South Africa.

(3) That, so far as circumstances admit, the award be made annually.

(*d*) The British Association has expressed a desire that the award shall be made only to those persons whose Scientific work is likely to be usefully continued by them in the future.

III.—AWARDS.

(*a*) Any individual engaged in Scientific research in South Africa shall be eligible to receive the award.

(*b*) The Medal and the available balance of one year's income from the Funds shall be awarded to one candidate only in each year (save in the case of joint research); to any candidate once only; and to no member of the Medal Committee.

(*c*) Nominations for the recipient of the award may be made by any Member of the South African Association for the Advancement of Science, and shall be submitted to the Medal Committee not later than six months after the close of the Annual Session.

(*d*) The Medal Committee shall recommend the recipient of the award to the Council, provided the recommendation is carried by the vote of at least a majority of three-fourths of its Members, voting verbally or by letter, and submitted to the Council at least one month prior to the Annual Session for confirmation.

(*e*) The award shall be made by the full Council of the South African Association for the Advancement of Science after considering the recommendations of the Medal Committee, provided it is carried by the vote of a majority of its Members, given in writing or verbally.

(*f*) The Council shall have the right to withhold the award in any

year, and to devote the funds rendered available thereby in subsequent award or awards, provided the stipulation contained in the second term of conveyance of the British Association is adhered to.

(*g*) No alteration shall be made in these Rules except under the condition specified in Chapter XIV of the Association's Constitution, reading:—

Any proposed alteration of the Rules:—

a. Shall be intimated to the Council three months before the next Session of the Association.

b. Shall be duly considered by the Council, and be communicated by circular to the Members of the Association for their consideration, and dealt with at the said Session of the Association.

(*h*) Should a Member of the Medal Committee accept nomination for the Award or be absent from South Africa at any time within four months before the commencement of the ensuing Annual Session, he will, ipso facto, forfeit his seat on the Committee.

B. The Goold-Adams Medals.*

(*a*) The Medals shall be awarded on the joint result of the Matriculation and University Senior Certificate Examination of the University of the Cape of Good Hope.

(*b*) One Medal shall be awarded to the student who has taken the highest place in each of the seven Science subjects: (1) Physics. (2) Chemistry, (3) Elementary Physical Science, (4) Botany, (5) Zoology, (6) Elementary Natural Science, and (7) Mathematics, as set forth in the University Matriculation and the University Senior Certificate Examination; and who is not over the prescribed age for Exhibitions at the Matriculation Examination.

(*c*) The standard of marks shall be not less than 65 per cent. of the maximum.

(*d*) The Medals shall be struck in bronze.

BYE-LAWS.

I. *Bye-laws under which the O.F.S. Philosophical Society was incorporated from* 1*st July*, 1914, *with the South African Association for the Advancement of Science, with the designation of "The Orange Free State Branch" of the Association.*

1. The O.F.S. Philosophical Society to be incorporated with the South African Association for the Advancement of Science, this being the only course of procedure open under the existing Constitution.

2. The title of the Society so incorporated to be "The Orange Free State Branch of the South African Association for the Advancement of Science."

3. All members of the South African Association for the Advancement of Science resident in the Orange Free State will, for the purpose of these bye-laws, be considered members of the Orange Free State Branch of the Association.

4. The local Committee of the Branch to consist of the Council members of the Association for the Orange Free State, together with such additional members as the Branch may elect to serve on its local Committee.

5. Subscription notices to members of the Branch to be circulated from the Head Office of the Association in Johannesburg, and subscriptions to be paid to the General Treasurer of the Association at Johannesburg, 10 per cent. thereof being remitted to the Orange Free State Branch for local expenses. Subscriptions of £1 10s. per annum to entitle to membership of the Association as a whole, as well as of the Orange Free State Branch.

* The award of these medals is at present suspended.

6. All members at present on the books of the Orange Free State Philosophical Society to be entitled to become members of the Association, to receive its Journal, and to enjoy the full privileges of membership, as soon as their subscriptions for the financial year 1914-15 shall have been paid.

7. Papers read before the Orange Free State Branch may either (1) be printed by title, abstract, or *in extenso,* in the Journal of the Association for the current year, after reference to the Presidents of the respective Sectional Committees, or (2) be read at the next Annual Session of the Association (provided that they have not been previously published in abstract or *in extenso*), and thereafter printed in the Association's Journal, subject to the ordinary conditions.

II. *Bye-laws for the guidance of Sectional Officers.*

1. The attention of all Sectional Officers is directed to Chapter XIII of the Association's Constitution, relating to the Sectional Committees and their functions.

2. The President and Recorder (or Secretary) of a Section shall have power during the Annual Session to act on behalf of the Section in any matter of urgency which cannot be brought before the consideration of the whole Sectional Committee; and they shall report such action to the next meeting of the Sectional Committee.

3. The President of the Section, or, in his absence, one of the two Vice-Presidents, shall preside at all meetings of the Section or of the Sectional Committee.

4. The President of the Section is expected to prepare a Presidential Address, which shall be delivered during the Annual Session.

5. Prior to the commencement of the Session, the Recorder of each Section shall prepare a list of all papers notified to be read during the Session, and shall also keep the Assistant Secretary of the Association informed of the titles and authors of all such papers. The Assistant Secretary shall, on his part, keep the Recorder informed of all papers that may be notified to him direct.

6. When a proposal is made for the reading of a paper at a joint meeting of Sections, the President, Recorder and Secretary of each Section shall, *ex officio*, attend a meeting convened by a General Secretary to consider the same.

7. During the continuance of the Annual Session, the Local Secretary of each Section shall be responsible for the punctual transmission to the Assistant Secretary of the daily programme of his Section for early publication, and of any other recommendations adopted by the Sectional Committee; and shall at the close of the Session furnish the Assistant Secretary with a list, showing which of the papers notified for reading before the Section have been so read, and which have been taken as read, and giving the dates in either case. He shall, at the same time, indicate the recommendations of the Sectional Committee with respect to each paper, *i.e.*, whether it should be printed in full, or in abstract, or by title only.

8. Each Sectional Committee shall cause to be prepared a record of the discussion on each paper read at its meeting; and such record shall be attached to the paper and handed in with the same in terms of Clause 11 of these instructions.

9. Each Sectional Committee shall, during the continuance of the Annual Session, meet daily, unless otherwise determined, to complete the arrangements for the next day.

10. In deciding on any recommendation regarding the printing of or otherwise of a paper submitted to it, the Sectional Committee shall consider only the merits of the paper, and not the financial condition of the Association.

11. The Local Secretary of each Section shall, at the close of each

day, collect the papers that have been read and hand them to the Assistant Secretary, together with a note explaining the cause of absence of any paper not so handed over.

12. Sectional Officers shall do their utmost to ensure punctual commencement and termination of the Section's daily proceedings; and, in drafting the programme for the next day, the Committee shall endeavour to allot a specified time to the reading and discussion of each paper, in order to prevent other Sections or the Association as a whole being inconvenienced in consequence of delays.

III. *Bye-laws for the Affiliation of Scientific and Kindred Societies.*

Philosophical and Scientific Societies, and other Associations of a kindred character may, on application to, and with the approval of the Council, affiliate with the South African Association for the Advancement of Science on the following conditions:—

1. That as a Society can only be affiliated on the approval of the Council, no minimum of membership of such Society need be specified.

2. That each Society shall pay the Association a minimum fee of £5 for a strength of 50 members or less, and a further £1 for each additional 10 or portion of 10 members.

3. That such Society shall be entitled to one copy of the South Afrcan Journal of Science for each £1 10s. paid to the Association.

4. That such Society may, if it has a strength of 50 members, be represented on the Council of the Association by its President or such other member as may be nominated for the purpose.

5. That all members of affiliated Societies may join the Association as ordinary members, with full privileges, at a reduced annual subscripton of 25s.

6. That affiliated Societies shall be asked to take into consideration the admission of members of the Association into their Societies at a reduced subscription.

7. That papers contributed to affiliated Societies may, on recommendation of both their own Council and that of the Association, be printed in the Association's Journal of Science, after which the authors shall be entitled to reprints on the usual terms.

Table showing the Places and Dates of Meeting of the South African Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Foundation.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
Sir DAVID GILL, K.C.B., LL.D., F.R.S., F.R.S.E. Cape Town, April 27, 1903.	S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Sir Charles Metcalfe, Bart., M.I.C.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M. A.	J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S.
Sir CHARLES METCALFE, Bart., M.I.C.E. Johannesburg, April 4, 1904.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M. A.	T. Reunert, M.I.C.E. M.I.M.E.
THEODORE REUNERT, M.I.C.E., M.I.M.E. Johannesburg, August 28, 1905.	J. Fletcher, A.M.I.C.E. S. J. Jennings, M.Amer.I.M.E. M.I.M.E. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Gardner F. Williams, M. A.	W. Cullen.
GARDNER F. WILLIAMS, M.A. Kimberley, July 9, 1906.	J. Burtt-Davy, F.L.S., F.R.G.S. James Hyslop, D.S.O., M.B., C.M. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	W. M. Wallace, A.R.C.S., A.M.I.C.E.
JAMES HYSLOP, D.S.O., M.B., C.M. Durban, July 16, 1907.	J. Burtt-Davy, F.L.S., F.R.G.S. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Thos. Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E. Prof. S. Schönland,, M.A., Ph.D., F.L.S., C.M.Z.S.	C. W. P. Douglas de Fenzi.
H.E. Hon. Sir WALTER HELY-HUTCHINSON, G.C.M.G., LL.D. Grahamstown, July 6, 1908.	Prof. J. C. Beattie, D.Sc., F.R.S.E. S. J. Jennings, M.Amer.I.M.E., M.I.M.E., M.I.M.M. Prof. S. Schönland,, M.A., Ph.D., F.L.S., C.M.Z.S. Ernest Williams, A.M.I.C.E., M.I.M.M.	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S. W. Hammond Tooke.
H.E. Sir HAMILTON GOOLD-ADAMS, G.C.M.G., C.B. Bloemfontein, September 27, 1909.	J. Burtt-Davy, F.L.S., F.R.G.S. Hugh Gunn, M.A. R. Marloth, M.A. ,Ph.D. Prof. S. Schönland,, M.A., Ph.D., F.L.S., C.M.Z.S.	Prof. G. Potts, M.Sc., Ph.D. A. Stead, B.Sc., F.C.S.
THOMAS MUIR, C.M.G., M.A., LL.D., F.R.S. F.R.S.E. Cape Town, October 31, 1910.	W. Cullen Hugh Gunn, M.A. Prof. P. D. Hahn, M.A., Ph.D. J. M. P. Muirhead, F.S.S., F.R.S.E.	C. F. Juritz, M.A., D.Sc., F.I.C.
Professor PAUL DANIEL HAHN, M.A., Ph.D. Bulawayo, July 3, 1911.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. C W. Howard, B.A., F.E.S. A. J. C. Molyneux, F.G.S., F.R.G.S. A. Theiler, C.M.G.	G. N. Bromehead.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES.
ARNOLD THEILER, C.M.G., D.Sc. Port Elizabeth, July 1, 1912.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. J. Moir, M.A., D.Sc., F.C.S. A. J. C. Molyneux, F.G.S., F.R.G.S. W. Arnott	E. G. Bryant, B.A., B.Sc.
ALEXANDER W. ROBERTS, D.Sc., F.R.A.S. F.R.S.E. Lourenço Marques, July 7, 1913.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. R. T. A. Innes, F.R.A.S., F.R.S.E. A. J. C. Molyneux, F.G.S., F.R.G.S. J. H. von Hafe	H. E. Wood, M.Sc., F.R.Met.S.
Professor RUDOLF MARLOTH, M.A., Ph D Kimberley, July 6, 1914	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. S. Evans W. Johnson, L.R.C.P., L.R.C.S. A. F. Williams, B.Sc.	A. F. Williams, B.Sc. F. Harrison.
ROBERT T. A. INNES, F.R.A.S., F.R.S.E. Pretoria, July 5, 1915.	Prof. L. Crawford, M.A., D.Sc., F.R.S.E. G. W. Herdman, M.A., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc. A. H. Watkins, M.D., M.R.C.S., M.L.A.	E. Hope Jones.
Professor LAWRENCE CRAWFORD, M.A., D.Sc., F.R.S.E. Maritzburg, July 3, 1916.	Rev. W. Flint, D.D. Lieut.-Col. J. Hyslop, D.S.O., M.B., C.M. Prof. J. Orr, B.Sc., M.I.C.E. Sir Arnold Theiler, K.C.M.G., D.Sc.	Prof. W. N. Roseveare, M.A.
Professor JOHN ORR, B.Sc., M.I.C.E., M.I.Mech.E. Stellenbosch, July 2, 1917.	A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. Prof. E. H. L. Schwarz, A.R.C.S., F.G.S. H. E. Wood, M.Sc., F.R.Met.S.	Prof. B. de St. J. van der Riet, M.A., Ph.D.
CHARLES F. JURITZ, M.A., D.Sc., F.I.C. Johannesburg, July 8, 1918.	W. Ingham, M.I.C.E., M.I.M.E. A. H. Reid, F.R.I.B.A., F.R.San.I. Prof. W. N. Roseveare, M.A. H. E. Wood, M.Sc., F.R.Met.S.	J. A. Foote, F.G.S., F.E.I.S.
Rev. WILLIAM FLINT, D.D. Kingwilliamstown, July 7, 1919.	P. Cazalet, M.I.M.M. Prof. J. E. Duerden, M.Sc., Ph.D. W. Ingham, M.I.C.E., M.I.M.E. Prof. E. Warren, D.Sc.	F. A. O. Pym.
ILTYD BULLER POLE-EVANS, M.A., D.Sc., F.L.S. Bulawayo, July 14, 1920.	Prof. J. W. Bews, M.A., D.Sc. Prof. J. E. Duerden, M.Sc., Ph.D. Prof. R. Leslie, M.A., F.S.S. Prof. J. A. Wilkinson, M.A., F.C.S.	D. Niven.
Professor J. E. DUERDEN, M.Sc., Ph.D., A.R.C.S. Durban, July 11, 1921.	Prof. G. E. Cory, M.A., D.Lit. Prof. R. Leslie, M.A., F.S.S. T. R. Sim, D.Sc. Prof. J. A. Wilkinson, M.A., F.C.S.	P. A. van der Bijl, M.A., D.Sc., F.L.S.

Presidents and Secretaries of the Sections of the Association.

Date and Place.	Presidents.	Secretaries.
SECTION A.—ASTRONOMY, CHEMISTRY, MATHEMATICS, METEOROLOGY AND PHYSICS.		
1903. Cape Town ..	Prof. P. D. Hahn, M.A., Ph.D.	Prof. L. Crawford.
1904. Johannesburg*	J. R. Williams, M.I.M.M., M.Amer.I.M.E.	W. Cullen, R. T. A. Innes.
1906. Kimberley	J. R. Sutton, M. A.	W. Gasson, A. H. J. Bourne.
1907. Natal†	E. N. Neville, F.R.S. F.R.A.S., F.C.S	D. P. Reid, G. S. Bishop.
1908. Grahamstown	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	D. Williams, G. S. Bishop.
ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODESY, SURVEYING, ENGINEERING, ARCHITECTURE AND GEOGRAPHY.		
1909. Bloemfontein	Prof. W. A D. Rudge, M.A.	H. B. Austin, F. Masey.
1910. Cape Town‡ ...	Prof. J. C. Beattie, D.Sc., F.R.S.E.	A. H. Reid, F. Flowers.
1911. Bulawayo	Rev. E. Goetz, S.J., M.A., F.R.A.S.	A. H. Reid, Rev. S. S. Dornan.
1912. Port Elizabeth	H. J. Holder, M.I.E.E.	A. H. Reid.
1913. Lourenço Marques	J. H. von Hafe.	Prof. J. Orr, J. Vafi Gomes.
1914. Kimberley	Prof. A. Ogg, M.A., B.Sc., Ph.D.	Prof. A. Brown, A. E. H. Dinham-Peren.
1915. Pretoria	E. E. Kanthack, M.I.C.E., M.I.M.E.	Prof. A. Brown, J. L. Soutter.
1916. Maritzburg ...	Prof. J. Orr, B.Sc. M.I.C.E.	Prof. A. Brown, P. Mesham.
1917. Stellenbosch ...	Prof. W. N. Roseveare, M.A.	Prof. A. Brown, L. Simons.
1918. Johannesburg	Prof. J. T. Morrison, M.A., B.Sc., F.R.S.E.	Prof. A. Brown, Prof. J. P. Dalton.
1919. Kingwilliamstown.	W. Ingham, M.I.C.E., M.I.M.E.	Dr. J. Lunt, T. G. Caink, J. Powell.
1920. Bulawayo	H. E. Wood, M.Sc., F.R.A.S.	Prof. J. Orr, A. C. Jennings.
1921. Durban	J. Lunt, D.Sc.	Prof. J. Orr, H. Clark.
SECTION B.—ANTHROPOLOGY, ETHNOLOGY, BACTERIOLOGY, BOTANY, GEOGRAPHY, GEOLOGY, MINERALOGY AND ZOOLOGY.		
1903. Cape Town ...	R. Marloth, M.A., Ph.D.	Prof. A. Dendy.
1904. Johannesburg	G. S. Corstorphine, B.Sc., Ph.D., F.G.S.	Dr. W. C. C. Pakes, W. H. Jollyman.
1906. Kimberley	Thos. Quentrall, M.I.M.E., F.G.S.	C. E. Addams, H. Simpson.
CHEMISTRY, METALLURGY, MINERALOGY, ENGINEERING, MINING AND ARCHITECTURE.		
1907. Natal	C. W. Methven, M.I.C.E., F.R.S.E., F.R.I.B.A.	R. G. Kirkby, W. Paton.
1908. Grahamstown	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	Prof. G. E. Cory, R. W. Newman, J. Muller.

* Metallurgy added in 1904.

† Geography and Geodesy transferred to Section A and Chemistry and Metallurgy to Section B in 1907.

‡ Irrigation added in 1910 and Geography transferred to Section B.

Date and Place.	Presidents.	Secretaries.

CHEMISTRY, BACTERIOLOGY, GEOLOGY, BOTANY, MINERALOGY, ZOOLOGY, AGRICULTURE, FORESTRY, SANITARY SCIENCE.

1909.	Bloemfontein	C. F. Juritz, M.A., D.Sc., F.I.C.	Dr. G. Potts, A. Stead.

CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY AND GEOGRAPHY.

1910.	Cape Town ...	A. W. Rogers, M.A., Sc.D., F.G.S.	J. G. Rose, G. F. Ayers.
1911.	Bulawayo	A. J. C. Molyneux, F.G.S., F.R.G.S.	J. G. Rose, G. N. Blackshaw.
1912.	Port Elizabeth	Prof. B. de St. J. van der Riet, M.A., Ph.D.	J. G. Rose, J. E. Devlin.
1913.	Lourenço Marques	Prof. R. B. Young, M.A., D.Sc., F.R.S.E., F.G.S.	Prof. G. H. Stanley, Captain A. Graça.
1914.	Kimberley	Prof. G. H. Stanley, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C.	J. G. Rose, J. Parry.
1915.	Pretoria...	H. Kynaston, M.A., F.G.S.	Dr. H. C. J. Tietz, Prof. D. F. du Toit Malherbe.
1916.	Maritzburg... ...	Prof. J. A. Wilkinson, M.A., F.C.S.	Dr. H. C. J. Tietz, Prof. J. W. Bews.
1917.	Stellenbosch ...	Prof. M. M. Rindl, Ing.D.	Dr. H. C. J. Tietz, Prof. B. de St. J. van der Riet.
1918.	Johannesburg	P. A. Wagner, Ing.D., B.Sc.	Dr. H. C. J. Tietz, Dr. J. Moir.
1919.	Kingwilliamstown.	H. H. Green, D.Sc., F.C.S.	Prof. J. A. Wilkinson, T. H. Harrison, W. G. Chubb.
1920.	Bulawayo	F. P. Mennell, F.G.S., M.I.M.M.	J. M. Hutcheon, A. M. MacGregor.
1921.	Durban	J. Moir, M.A., D.Sc., F.I.C.	Prof. J. A. Wilkinson, A. Kloot.

SECTION C.—AGRICULTURE, ARCHITECTURE, ENGINEERING, GEODESY, SURVEYING AND SANITARY SCIENCE.

1903.	Cape Town ...	Sir Charles Metcalfe, Bart., M.I.C.E.	A. H. Reid.
1904	Johannesburg*	Lieut.-Colonel Sir Percy Girouard, K.C.M.G., D.S.O.	G. S. Burt Andrews, E. J. Laschinger.
1906.	Kimberley	S. J. Jennings, C.E., M.Amer.I.M.E., M.I.M.E.	D. W. Greatbatch, W. Newdigate.

BACTERIOLOGY, BOTANY, ZOOLOGY, AGRICULTURE AND FORESTRY, PHYSIOLOGY, HYGIENE.

1907.	Natal	Lieut.-Colonel H. Watkins-Pitchford, F.R.C.V.S.	W. A. Squire, A. M. Neilson, Dr. J. E. Duerden.
1908.	Grahamstown	Prof. S. Schonland, M.A., Ph.D., F.L.S., C.M.Z.S.	Dr. J. Bruce Bays, W. Robertson, C. W. Mally, Dr. L. H. Gough.
1910.	Cape Town† ...	Prof. H. H. W. Pearson, M.A., Sc.D., F.L.S.	W. D. Severn, Dr. J. W. B. Gunning.
1911.	Bulawayo	F. Eyles, F.L.S., M.L.C.	W. T. Saxton, H. G. Mundy.
1912.	Port Elizabeth	F. W. FitzSimons, F.Z.S., F.R.M.S.	W. T. Saxton, I. L. Drège.
1913.	Lourenço Marques	A. L. M. Bonn, C.E.	F. Flowers, Lieut. J. B. Bothelho.
1914.	Kimberley	Prof. G. Potts, M.Sc., Ph.D.	C. W. Mally, W. J. Calder.
1915.	Pretoria...	C. P. Lounsbury, B.Sc., F.E.S.	C. W. Mally, A. K. Haagner.
1916.	Maritzburg ...	I. B. Pole-Evans, M.A., B.Sc., F.L.S.	C. W. Mally, Prof. E. Warren.
1917.	Stellenbosch ...	J. Burtt-Davey, F.L.S., F.R.G.S.	C. W. Mally, C. S. Grobbelaar.

* Forestry added in 1904.
† Sanitary Science added in 1910.

Date and Place	Presidents.	Secretaries.

BOTANY, BACTERIOLOGY, AGRICULTURE AND FORESTRY.

1918. Johannesburg	C. E. Legat, B.Sc.	Dr. E. P. Phillips, J. Burtt-Davy.
1919. Kingwilliamstown	Ethel M. Doidge, M.A., D.Sc., F.L.S.	Dr. E. P. Phillips, E. W. Dwyer, Dr. G. Rattray.
1920. Bulawayo	T. R. Sim, D.Sc., F.L.S.	Dr. E. P. Phillips, Prof. H. A. Wager.
1921. Durban	Prof. J. W. Bews, M.A., D.Sc.	Prof. H. A. Wager, Dr. H. F. Standing.

SECTION D.—ZOOLOGY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

1918. Johannesburg	Prof. E. J. Goddard, B.A., D.Sc.	C. W. Mally, R. J. Ortlepp
1919. Kingwilliamstown	Prof. E. Warren, D.Sc.	C. W. Mally, Dr. J. I. Brownlee, B. H. Dodd.
1920. Bulawayo	C. W. Mally, M.Sc., F.E.S.	Dr. Annie Porter, P. H. Taylor.
1921. Durban	Prof. H. B. Fantham, M.A., D.Sc.	Dr. Annie Porter, E. C. Chubb.

SECTION E.—ANTHROPOLOGY, ETHNOLOGY, ECONOMICS, SOCIOLOGY AND STATISTICS.

1908. Grahamstown	W. Hammond Tooke.	Prof. A. S. Kidd.

ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, AND NATIVE SOCIOLOGY.

1917. Stellenbosch ...	Rev. N. Roberts.	Rev. E. W. H. Musselwhite, Prof. J. J. Smith.
1918. Johannesburg	Rev. W. A. Norton, B.A., B.Litt.	Rev. E. W. H. Musselwhite, Rev. G. Evans.
1919. Kingwilliamstown	Rev. J. R. L. Kingon, M.A., F.R.S.E., F.L.S.	Rev. E. W. H. Musselwhite, G. R. Spencer, M. Flemmer.
1920. Bulawayo	Rev. H. A. Junod.	N. H. Wilson, Rev. N. Jones.
1921. Durban	C. T. Loram, M.A., LL.B., Ph.D.	Rev. N. Roberts, P. E. Chandley.

SECTION F.—ARCHÆOLOGY, EDUCATION, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

1903. Cape Town ...	Thomas Muir, C.M.G., M.A., LL.D., F.R.S., F.R.S.E.	Prof. H. E. S. Fremantle.
1904. Johannesburg	(Sir Percy Fitzpatrick, M.L.A.), E. B. Sargant, M.A. (Acting).	Howard Pim, J. Robinson.
1906. Kimberley	A. H. Watkins, M.D., M.R.C.S.	E. C. Lardner-Burke, E. W. Mowbray.

ANTHROPOLOGY, ARCHÆOLOGY, ECONOMICS, EDUCATION, ETHNOLOGY, HISTORY, PSYCHOLOGY, PHILOLOGY, SOCIOLOGY AND STATISTICS.

1907. Natal	R. D. Clark, M.A.	R. A. Gowthorpe, A. S. Langley, E. A. Belcher.

ARCHÆOLOGY, EDUCATION, HISTORY, PSYCHOLOGY AND PHILOLOGY.

1908. Grahamstown	E. G. Gane, M. A.	Prof. W. A. Macfadyen, W. D. Neilson.

ANTHROPOLOGY, ETHNOLOGY, EDUCATION, HISTORY, MENTAL SCIENCE, PHILOLOGY, POLITICAL ECONOMY, SOCIOLOGY AND STATISTICS.

Date and Place.	Presidents.	Secretaries.
1909. Bloemfontein ..	Hugh Gunn, M.A.	C. G. Grant, Rev. W. A. Norton.
1910. Cape Town ...	Rev. W. Flint, D.D.	G. B. Kipps, W. E. C. Clarke.
1911. Bulawayo	G. Duthie, M.A., F.R.S.E.	G. B. Kipps, W. J. Shepherd.
1912. Port Elizabeth	W. A. Way, M.A.	G. B. Kipps, E. G. Bryant.
1913. Lourenço Marques	J. A. Foote, F.G.S	H. Pim, J. Elvas.
1914. Kimberley	Prof. W. Ritchie, M.A.	Prof. R. D. Nauta, A. H. J. Bourne.
1915. Pretoria...	J. E. Adamson, M.A.	Prof. R. D. Nauta, R. G. L. Austin.
1916. Maritzburg ..	M. S. Evans, C.M.G., F.Z.S.	Prof. R. D. Nauta, Prof. O. Waterhouse.

EDUCATION, HISTORY, MENTAL SCIENCE, POLITICAL ECONOMY, GENERAL SOCIOLOGY AND STATISTICS.

1917. Stellenobsch ...	Rev. B. P. J. Marchand, B.A.	Prof. R. D. Nauta, Dr. Bertha Stoneman.
1918. Johannesburg	Prof. T. M. Forsyth, M.A., D.Phil.	Prof. R. D. Nauta, J. Mitchell.
1919. Kingwilliamstown	Prof. R. Leslie, M.A., F.S.S.	Prof. R. D. Nauta, J. Wood, F. J. Cherrigh.
1920. Bulawayo	Prof. R. A. Lehfeldt, B.A., D.Sc.	J. Mitchell, B. M. Narbeth.
1921. Durban	Prof. W. A. Macfadyen, M.A., LL.D.	J. A. Foote, B. M. Narbeth.

EVENING DISCOURSES.

Date and Place.	Lecturer.	Subject of Discourse.
1903. Cape Town ..	Prof. W. S. Logeman, B.A., L.H.C.	The Ruins of Persepolis and how the Inscriptions were read.
1904. Johannesburg	H. S. Hele-Shaw, LL.D., F.R.S., M.I.C.E.	Road Locomotion—Present and Future.
1906. Kimberley . .	Prof. R. A. Lehfeldt, B.A., D.Sc.	The Electrical Aspect of Chemistry.
	W. C. C. Pakes, L.R.C.P., M.R.C.S., D.P.H., F.I.C.	The Immunisation against Disease of Micro-organic Origin.
1907. Maritzburg ...	R. T. A. Innes, F.R.A.S., F.R.S.E.	Some Recent Problems in Astronomy.
Durban	Prof. R. B. Young, M.A., B.Sc., F.R.S.E., F.G.S.	The Heroic Age of South African Geology.
1908. Grahamstown	Prof. G. E. Cory, M.A.	The History of the Eastern Province.
	A. Theiler, C.M.G.	Tropical and Sub-tropical Diseases of South Africa: their Causes and Propagation.
1909. Bloemfontein ...	C. F. Juritz, M.A., D.Sc., F.I.C.	Celestial Chemistry.
	W. Cullen.	Explosives: their Manufacture and Use.
Maseru	R. T. A. Innes, F.R.A.S. F.R.S.E.	Astronomy.

Date and Place.	Lecturer.	Subject of Discourse.
1910. Cape Town ...	Prof. H. Bohle, M.I.E.E.	The Conquest of the Air.
1911. Bulawayo	J. Brown, M.D., C.M., F.R.C.S., L.R.C.S.E.	Electoral Reform—Proportional Representation.
	W. H. Logeman, M.A.	The Gyroscope.
1912. Port Elizabeth	A. W. Roberts, D.Sc., F.R.A.S., F.R.S.E.	Imperial Astronomy.
	Prof. E. J. Goddard, B.A., D.Sc.	Antarctica.
1913. Lourenço Marques	S. Seruya.	The History of Portuguese Conquest and Discovery.
1914. Kimberley	Prof. E. H. L. Schwarz, A.R.C.S., F.G.S.	The Kimberley Mines, their Discovery and their Relation to other Volcanic Vents in South Africa.
1915. Pretoria...	E. T. Mellor, D.Sc., F.G.S., M.I.M.M.	The Gold-bearing Conglomerates of the Witwatersrand.
	C. W. Mally, M.Sc., F.E.S., F.L.S.	The House Fly under South African conditions.
1916. Maritzburg ...	C. P. Lounsbury, B.Sc., F.E.S.	Scale Insects and their travels.
Durban	R. T. A. Innes, F.R.A.S., F.R.S.E.	Astronomy.
1917. Stellenbosch ...	H. E. Wood, M.Sc., F.R.Met.S.	Some Unsolved Problems of Astronomy.
	Prof. J. D. F. Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S.	Some Marine Animals of South Africa.
1918. Johannesburg	Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S.	Evolution and Mankind.
	Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S.	Ostriches.
1919. Kingwilliamstown	Prof. E. J. Goddard, B.A., D.Sc.	The Approaching South African Antarctic Expedition.
East London ...	Prof. G. E. Cory, M.A.	Early History of Kaffraria and East London.
1920. Bulawayo	Prof. J. A. Wilkinson, M.A., F.C.S.	The Nitrogen Problem.
1921. Durban	A. L. du Toit, D.Sc., F.G.S.	Land Connections between the other Continents and South Africa in the Past.

MEETINGS AT DURBAN.

On *Monday, July* 11, 1921, at 11 a.m., the Association was officially welcomed by His Worship the Mayor of Durban (Councillor Fleming Johnston, J.P.) and the Borough Council in the Arthur Smith Hall of the Technical College. Professor J. E. Duerden, President of the Association, responded.

Previously, at 10 a.m., there had been a meeting of Council.

At 11.30 a.m., Dr. J. Lunt delivered an address, as President of Section A, on "Stellar Distances, Magnitudes and Movements."

In the afternoon there were Sectional Meetings.

At 8.15 p.m., Professor J. E. Duerden, M.Sc., Ph.D., President, delivered an address on "Social Anthropology in South Africa: Problems of Race and Nationality" in the Arthur Smith Hall, Dr. S. G. Campbell presiding. (See page 1.)

The President subsequently presented the South Africa Medal to Sir Spencer Lister. (See page xxxii.)

On *Tuesday, July* 12, at 9.30 a.m., Dr. J. Moir, F.I.C., delivered an address, as President of Section B, on "The Atomic Theory in 1921." At 11.15 a.m., Professor H. B. Fantham, M.A., D.Sc., delivered an address, as President of Section D, on "Some Recent Advances in Zoology, and their Relation to Present-Day Problems."

At 2 p.m., Members of the Association proceeded on motor trips to the Natal Sugar Estates, Mount Edgecumbe, to the Match Factory at Umgeni, or to Sarnia.

At 8 p.m., Members attended a reception by His Worship the Mayor in the Art Gallery.

On *Wednesday, July* 13, at 9.30 a.m., Professor W. A. Macfadyen, M.A., LL.D., delivered an address, as President of Section F, on "Observations and Proposals for the Stabilisation of Money Values."

Sectional Meetings took place at 10.30 a.m., except in Section C, whose members proceeded on an ecological excursion to Isipingo.

At 2.30 p.m., Dr. C. T. Loram, LL.B., delivered an address, as President of Section E, on "The Claims of the Native Question upon Scientists." Sectional Meetings followed.

On *Thursday, July* 14, at 9.30 a.m., Professor J. W. Bews, M.A., D.Sc., delivered an address, as President of Section C, on "Some Aspects of Botany in South Africa and Plant Ecology in Natal."

At 11 a.m. the Nineteenth Annual General Meeting was held in the Technical College, for the Minutes of which see page xxii.

At 2 p.m., Members proceeded on excursions to Messrs. Lever Bros.' soap works at Congella, or to the sugar refinery of Sir J. L. Hulett and Sons at South Coast Junction.

At 8 p.m., Members attended a Conversazione in the Arthur Smith Hall, held by the Local and Reception Committees and the Natal Society for the Advancement of Science and Art.

On *Friday, July* 15, at 9.30 a.m., there was a meeting of Council. At 10.30 a.m. there were Sectional Meetings.

At 2 p.m., Members proceeded on excursions to the Indian market, Municipal Native eating house and Native brewery, or to the Municipal telephone exchange, Fire station, and the Old Fort, or to the Natal Cane By-products' factory at Merebank.

At 8.15 p.m., Dr. A. L. du Toit, B.A., F.G.S., gave a popular, illustrated lecture on "Land Connections between the other Continents and South Africa in the Past," in the Arthur Smith Hall, the President of the Association presiding.

On *Saturday, July* 16, at 9.30 a.m., Members proceeded on a trip on the Bay, visiting the coaling plant and oil tanks on the Bluff. There was a zoological excursion in the afternoon.

OFFICERS OF LOCAL AND SECTIONAL COMMITTEES, DURBAN, 1921.

LOCAL COMMITTEE.

Chairman, J. Kirkman, J.P.; *Hon. Secretary*, P. A. van der Bijl, M.A., D.Sc., F.L.S.; *Members*, C. M. Campbell, E. Campbell, S. G. Campbell, M.D., M.Ch., M.R.C.S., D.P.H.; F. G. Cawston, B.A., M.D., M.R.C.S., L.R.C.P., Senator the Hon. F. Churchill, Colonel J. Dick, H. H. Dodds, M.Sc., H. A. Dumat, M.D., F.R.C.P., F.C.S., E. B. Dunkerton, D. M. Eadie, R.P.A., F. Goodall, W. Greenacre, O.B.E., M.L.A., L. C. Grice, M.C.; C. Hall, A.M.I.C.E., E. A. Halm, B.A., A. Kloot, B.Sc., A.I.C., A. MacKenzie, M.D., M.R.C.S., B. M. Narbeth, B.Sc., F.C.S., A. MacNay, M.I.Mech.E., J. St. Guido Reynolds-Tait, P. Roux, E. A. Selke, B.A., O. Siedle, A. H. Smith, O.B.E., Senator the Hon. C. G. Smith, C. P. van der Merwe, B. W. Wade, Brig.-Gen. J. S. Wylie, K.C., D.S.O., M.V.O., Rev. A. E. le Roy, B.A., B.D., L. R. D. Anderson, M.C., M.A.

RECEPTION COMMITTEE.

Chairman, His Worship the Mayor, Councillor Fleming Johnston, J.P.; *Hon. Secretary*, P. A. van der Bijl, M.A., D.Sc., F.L.S.; *Members*, Councillors G. Mitchell, R. A. Barton, Mrs. E. A. Benson, T. Burman, M.B.E., J.P., I. Davis, Dr. C. A. Francois, W. Gilbert, J. E. Hay, C. Henwood, J. Hutt, C. W. Lennox, J. Mayhew, J. Nicol, L. Renaud, T. C. Shearer, T. C. C. Sloane, T. M. Wadley, A. Buchanan, John Taylor, Geo. Carter, Dr. H. J. Balfe, M.D., E. W. Evans, C. F. Hignett, P. D. Bray, O.B.E., F. J. Lennox, W. Greenacre, O.B.E., M.L.A., Senator F. F. Churchill, Wallis Short, C. Hinks, A. H. Oliver, E. W. Dyer, M.B., F.R.C.S., H. Wodson, J. Drummond, M.D., M.R.C.P., E. O. Payne, A.R.I.B.A., F. C. Hollander, M.E.C., E. G. A. Saunders, M.L.A., Wm. Pearce, R. Ellis Brown, D. M. Shaw, A.M.I.C.E., A. E. Hurley, S. G. Campbell, M.D., M.Ch., M.R.C.S., G Halley, J. Kirkman, J.P., F. Goodall, Uley Sargent, R. H. Wisely, E. Price, J. R. More, Col. Friend Addison, Meyrick Bennett, T. Boydell, M.L.A., W. Butcher, L. Byron, M.P.C., C. F. Clarkson, M.P.C., J. Coleman, M.P.C., F. J. Fahey, M.P.C., A. E. Green, M.P.C., G. H. Hulett, M.P.C., Sir Liege Hulett, J. W. Henderson, M.L.A., G. Heaton-Nicolls, M.L.A., J. H. Nicolson, O.B.E., M.P.C., Sir Frank Reynolds, C. P. Robinson, M.L.A., W. D. Russell, M.P.C., A. H. Smith, O.B.E., Senator the Hon. C. G. Smith, Brig.-Gen. J. S. Wylie, K.C., D.S.O., M.V.O.

SECTIONAL COMMITTEES.

Section A.—ASTRONOMY, MATHEMATICS, PHYSICS, METEOROLOGY, GEODOSY, SURVEYING, ENGINEERING, ARCHITECTURE, AND IRRIGATION.

President, J. Lunt, D.Sc.; *Vice-Presidents*, Prof. R. W. Varder, M.A., Prof. P. G. Gundry, B.Sc., Ph.D., A.R.C.S.; *Members*, Prof. L. Crawford, M.A., D.Sc., F.R.S.E., W. Ingham, M.I.C.E., M.I.M.E., Prof. P. Mesham, M.A., M.Sc., Prof. W. N. Roseveare, M.A., H. E. Wood, M.Sc., F.R.A.S., F.R.Met.S.; *Recorder*, Prof. J. Orr, O.B.E., B.Sc., M.I.C.E.; *Secretary*, H. Clark, B.Sc., A.C.G.I., A.M.I.E.E.

Section B.—CHEMISTRY, GEOLOGY, METALLURGY, MINERALOGY, GEOGRAPHY.

President, J. Moir, M.A., D.Sc., F.I.C., F.C.S.; *Vice-Presidents*, Prof. G. E. Cory, M.A., Prof. S. J. Shand, Ph.D., D.Sc., F.G.S.; *Members*, C. F. Juritz, M.A., D.Sc., F.I.C., Prof. D. F. du T. Malherbe, M.A., Ph.D., Prof. M. M. Rindl, Ing.D., Prof. H. C. J. Tietz, M.A., Ph.D., P. A. Wagner, Ing.D., B.Sc.; *Recorder*, Prof. J. A. Wilkinson, M.A., F.C.S.; *Secretary*, A. Kloot, B.Sc., A.I.C.

Section C.—BOTANY, BACTERIOLOGY, AGRICULTURE, FORESTRY.

President, Prof. J. W. Bews, M.A., D.Sc.; *Vice-Presidents*, Miss Bertha Stoneman, D.Sc., E. P. Phillips, M.A., D.Sc., F.L.S.; *Members*, P. A. van der Bijl, M.A., D.Sc., F.L.S., Ethel M. Doidge, M.A., D.Sc., F.L.S., Prof. C. E. Moss, M.A., D.Sc., F.L.S., F.R.G.S., Prof. D. Thoday, M.A., I. B. Pole-Evans, C.M.G., D.Sc., F.L.S.; *Recorder*, Prof. H. A. Wager, A.R.C.S.; *Secretary*, H. F. Standing, D.Sc.

Section D.—ZOOLOGY, PHYSIOLOGY, HYGIENE, SANITARY SCIENCE.

President, Prof. H. B. Fantham, M.A., D.Sc., A.R.C.S., F.Z.S.; *Vice-Presidents*, A. J. Orenstein, C.M.G., M.D., Annie Porter, D.Sc., F.L.S.; *Members*, Prof. E. H. Cluver, B.A., M.B., B.Ch., Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S., Sir F. S.

Lister, M.R.C.S., L.R.C.P., C. W. Mally, M.Sc., F.E.S., D. T. Mitchell, M.R.C.V.S., P. J. du Toit, B.A., Ph.D., Dr.Med.Vet., Prof. E. Warren, D.Sc.; *Recorder*, Annie Porter, D.Sc.; *Secretary*, E. C. Chubb, F.Z.S., F.E.S.

Section E.—ANTHROPOLOGY, ETHNOLOGY, NATIVE EDUCATION, PHILOLOGY, NATIVE SOCIOLOGY.

President, C. T. Loram, M.A., LL.B., Ph.D.; *Vice-Presidents*, S. G. Campbell, M.D., M.Ch., F.R.C.S.E., M.R.C.S., D.P.H., Miss M. Wilman; *Members*, Rev. G. Evans, H. S. Keigwin, M.A., Rev. J. R. L. Kingon, M.A., F.R.S.E., Rev. W. A. Norton, M.A., B.Litt.; *Recorder*, Rev. Noel Roberts; *Secretary*, P. E. Chandley.

Section F.—EDUCATION, HISTORY, MENTAL SCIENCE, PRACTICAL ECONOMY, GENERAL SOCIOLOGY, STATISTICS.

President, Prof. W. A. Macfadyen, M.A., LL.D.; *Vice-Presidents*, Prof. F. Clarke, M.A., G. T. Morice, B.A., K.C.; *Members*, Rev. W. Flint, D.D., J. E. Adamson, M.A., D.Lit., Prof. T. M. Forsyth, M.A., D.Phil., Prof. R. Leslie, M.A., F.S.S., Prof. W. M. Macmillan, M.A., Mrs. M. Palmer, M.A.; *Recorder*, J. A. Foote, F.G.S., F.E.I.S.; *Secretary*, B. M. Narbeth, B.Sc., F.Ph.S.

PROCEEDINGS OF THE NINETEENTH ANNUAL GENERAL MEETING OF MEMBERS, HELD IN THE TECHNICAL COLLEGE, DURBAN, ON THURSDAY, JULY 14, 1921, AT 10 a.m.

PRESENT: Prof. J. E. Duerden, M.Sc., Ph.D., A.R.C.S., F.Z.S. (President) in the Chair; Mr. R. D. Aitken, Mr. J. L. Andrew, Mrs. O. W. Ball, Prof. J. W. Bews, Mr. Graham Botha, Dr. S. G. Campbell, Mr. E. C. Chubb, Mr. N. Clark, Prof. E. H. Cluver, Rev. A. Constantine, Prof. G. E. Cory, Miss Frances de Wet, Col. Jas. Dick, Dr. A. L. du Toit, Prof. H. B. Fantham (Hon. Editor of Journal), Mr. G. J. Floyd, Mr. J. A. Foote, Miss H. M. L. Forbes, Mr. E. A. Halm, Miss G. L. Hebditch, Miss R. M. Hodges, Miss Alta Johnson, Mrs. Edith B. Jones, Mr. J. D. R. Jones, Mr. Walter P. Kennedy, Mr. T. N. Leslie, Dr. C. T. Loram, Dr. J. Lunt, Prof. W. A. Macfadyen, Mr. A. S. MacIntyre, Mrs. A. W. Marchand, Dr. B. de C. Marchand, Mrs. H. M. McKay, Adv. G. T. Morice, Mr. A. O. D. Mogg, Dr. James Moir, Mr. R. S. Morris, Mr. B. M. Narbeth, Prof. John Orr, Mrs. Mabel Palmer, Mr. E. Parish, Dr. Annie Porter (Hon. Librarian), Mr. J. B. Robertson, Prof. W. N. Roseveare, Mr. J. Sandground, Rev. W. E. Smyth, Miss S. Stafford, Dr. H. F. Standing, Dr. Bertha Stoneman, Miss C. L. T. Teasdale, Prof. D. Thoday, Mr. F. G. Tyers, Miss L. H. van der Koppel, Prof. H. A. Wager, Dr. E. Warren, Mr. C. O. Williams, Dr. C. F. Juritz (Hon. General Secretary), Mr. H. E. Wood (Hon. General Secretary), and H. A. G. Jeffreys (Assistant General Secretary.)

MINUTES.—The Minutes of the Eighteenth Annual Meeting held at Bulawayo on the 17th July, 1920, and printed on pp. xx—xxiii of the Report of the Bulawayo Session (vol. xvii, No. 1 of the Journal) were confirmed.

ANNUAL REPORT OF COUNCIL.—The Annual Report of the Council for 1920—21 having been suspended in the Main Hall since the 11th July, was taken as read and adopted. This Report will be found on p. xxiv of this issue.

REPORT OF THE HON. GENERAL TREASURER AND STATEMENTS OF ACCOUNTS FOR 1920-21.—The Hon. General Treasurer's Report and Financial Statements for 1920-21, which had been suspended in the Main Hall since 11th July, were taken as read and adopted. See pp. xxvii-xxxi. The President informed the meeting that owing to lack of funds the Council had found it necessary to withhold payment to the Trustees of the Endowment Fund of the Life Members' Subscriptions received during the two years 1919-1921. This action of the Council was unanimously confirmed.

ELECTION OF OFFICERS FOR 1921-22.—The following Officers were elected for 1921-22:—

President: Dr. A. W. Rogers, M.A., F.R.S.

Vice-Presidents: Prof. A. Brown, M.A., B.Sc., F.R.S.E.
Prof. R. B. Denison, D.Sc., Ph.D.
Mr. E. Farrar.
Prof. T. Forsyth, M.A., D.Phil.

Hon. General Secretaries:
Dr. C. F. Juritz, M.A., F.I.C.
Mr. H. E. Wood, M.Sc., F.R.A.S., F.R.Met.S.

Hon. General Treasurer: Mr. Jas. Gray, F.I.C.

Hon. Editor of Publications: Prof. H. B. Fantham, M.A., D.Sc.

Hon. Librarian: Dr. Annie Porter, F.L.S.

ELECTION OF COUNCIL MEMBERS FOR 1921-22:—

I. TRANSVAAL.—R. des Clayes, J. A. Foote, F.G.S., F.E.I.S., R. T. Innes, F.R.A.S., F.R.S.E., W. Ingham, M.I.C.E., M.I.M.E., Sir F. Spencer Lister, M.R.C.S., L.R.C.P., Dr. J. McCrae, F.I.C., Dr.

E. T. Mellor, M.I.M.M., F.G.S., Dr. J. Moir, M.A., F.I.C., Adv. G. T. Morice, B.A., K.C., Dr. A. J. Orenstein, C.M.G., M.R.C.S., L.R.C.P., Prof. J. Orr, O.B.E., B.Sc., M.I.C.E., A. M. Robb, M.A., S. Seruya, Prof. J. A. Wilkinson, M.A., F.C.S., P. J. du Toit, Ph.D., Dr. Med. Vet., P. G. Gundry, B.Sc., Ph.D., Mr. A. K. Haagner, Dr. E. P. Phillips, M.A.

II. Cape Province.—Prof. L. Crawford, M.A., D.Sc., F.R.S.E., Rev. W. Flint, D.D., Dr. J. Lunt, F.I.C., C. W. Mally, M.Sc., F.E.S., C. Graham Botha, Prof. R. Leslie, M.A., Miss M. Wilman, F. W. Fitzsimons, F.Z.S., F.R.M.S., Rev. J. R. L. Kingon, M.A., F.R.S.E., Prof. E. J. Goddard, B.A., D.Sc., Miss Alta Johnson, Ph.B., E. B. Dwyer, B.A.

III. Natal.—E. C. Chubb, F.Z.S., B. M. Narbeth, B.Sc., Prof. J. W. Bews, M.A., D.Sc., Prof. E. Warren, D.Sc.

IV. Orange Free State.—Prof. M. M. Rindl, Ing.D.

V. Rhodesia.—Rev. E. Goetz, S.J., M.A., H. B. Maufe, B.A., F.G.S.

VI. Mozambique.—S. Seruya.

There are still a few vacancies, and elections to fill them will be made by the Council.

Annual Session, 1922.—The President announced that an invitation from the Governor-General of Mozambique for the Association to hold its Annual Session in Lourenço Marques in 1922 had been received through Mr. S. Seruya, the Portuguese Vice-Consul in Johannesburg. On the motion of Dr. Annie Porter, seconded by Prof. J. Orr, it was unanimously decided that the invitation be accepted, and that a letter expressing gratification at the Governor-General's offer be sent to Mr. Seruya.

Associated Scientific and Technical Societies of South Africa.

Dr. Juritz enquired if any liability devolved upon the Association in respect of its connection with the Associated Scientific and Technical Societies of South Africa.

Prof. J. Orr, in reply, stated that the Associated Societies had been formed to carry out the scheme of closer working and joint housing, an object which had been under the consideration of the more important Scientific and Technical Societies for some years past. A handsome building had been acquired, which afforded a common meeting place for members of the constituent Societies, and also provided club facilities. Funds were urgently needed, and although the Constitution of the Association did not permit it to follow the example of other societies and donate a portion of its invested funds, an effort had been made to obtain contributions from individual members, and some seven hundred appeals had been sent out, signed by Mr. H. E. Wood and himself. The result had not been very satisfactory, but it was hoped to make a further attempt, and he suggested that the Journal of the Association might be used in bringing the matter to the notice of members. Legal opinion had been taken, and neither the Association nor its members were under any financial obligation to the Associated Societies.

Remission of Customs Duties on Scientific Instruments.

On the motion of Dr. J. Lunt, seconded by Dr. S. G. Campbell, it was resolved that the Association should take steps to secure remission of duties on scientific instruments, and that it be a request to the incoming Council to deal with the matter.

Victoria and Albert Museum Loan Collections.

On the motion of Mr. E. C. Chubb, seconded by Prof. J. Orr, it was resolved that the Council take into consideration the question

of asking the Union Government to apply to the Imperial Government for the collections of applied art belonging to the Victoria and Albert Museum, which at present are circulated for varying periods on loan among the provincial museums of the United Kingdom, and which might be similarly circulated amongst the museums of the Colonies.

Votes of Thanks.

Votes of Thanks.—On the motion of Dr. J. Lunt, it was carried with acclamation that the thanks of the Association be accorded to the following:—

(1) His Worship the Mayor and Town Council of Durban for their cordial welcome to the Association, for the evening reception and for the general facilities afforded to the members.

(2) The members of the Local Committee and the Reception Committee for their excellent arrangements for the meeting and for their untiring efforts on behalf of every visiting member of the Association.

(3) The Finance Committee for raising the necessary funds and to the various donors for their liberal contributions.

(4) The Hospitality Committee.

(5) The Transport, Excursions and Entertainments Committee for making arrangements for members to visit places of interest, and also the management of the following factories and firms for granting facilities for viewing their works:—

The Lion Match Factory.
Natal Estates, Mount Edgecombe.
Lever Bros.
Sir J. L. Hulett & Sons.
Natal By-Products Co.

(6) The Ladies' Committee and their friends for their kind hospitality in providing tea.

(7) The Council of the Technical College for granting the use of the College building, and also the governing bodies of the following institutions for the privileges allowed to members of the Association —

The Durban Club, Durban Turf Club, Durban Golf Club, Durban Borough Lawn Tennis Club, Royal Natal Yacht Club, Durban Bowling Club, Durban Rowing Club, Berea Lawn Tennis Club.

(8) The Press for their efforts in bringing the work of the Association prominently before the public.

(9) Dr. P. A. van der Bijl, Secretary of the Local Committee and the Reception Committee, for his efforts in the preparation for and throughout the visit of the Association.

On the motion of Prof. Orr it was unanimously agreed that the sincere thanks of the Association be accorded to the donors of funds to defray the cost of printing the Proceedings of the Session.

In proposing a very hearty vote of thanks to the President, Dr. S. G. Campbell referred to the masterly fashion and charming manner in which the various meetings had been conducted by Dr. Duerden, to which to a large extent was to be attributed the success of the session.

The President suitably replied, thanking Dr. Campbell on behalf of himself and all members of the Association.

REPORT OF THE COUNCIL FOR THE YEAR ENDED 30th June, 1921.

1. Obituary: Your Council has to report, with great regret, the deaths of the following members:—Mr. Frank Flowers, who was a Foundation Member and a Life Member of the Association; Mr. H. Gibson, Mr. J. M. Hutcheon, Mr. G. R. Perrins, and Mr. A. J. C. Molyneux (a former Vice-President).

2. Membership: Since the last report 43 new members have joined the Association; five have died; 32 have resigned; and 96 have

been removed from the register by resolution of the Council. The nett decrease in membership has therefore been 89.

The following comparative table, as from the 1st July in each year, shows the various Provinces from which members are drawn:—

	1920.		1921.
Transvaal	474	...	414
Cape Province	294	...	279
Orange Free State	45	...	40
Natal	92	...	98
Rhodesia	43	...	37
Mozambique	10	...	8
South-West Africa Protectorate ...	1	...	—
Abroad	21	...	15
Unknown	2	...	2
	982		893

3. The Journal: The publication of Volume XVI of the Kingwilliamstown, 1919, Meeting, was completed in September, 1920. Quarterly publication having been decided upon by the Council, the first part of Volume XVII, dealing with papers read at Bulawayo, 1920, Meeting, was published in November, 1920. The second part, dated April, 1921, was published in June, 1921, and the remaining papers are in the Press. An index is in preparation. It is regretted that not all the papers read could be published, owing to the high cost of paper and printing all over the world at the present time.

4. The Library: Owing to financial stringency, it is regretted that the binding of many publications has not been proceeded with, though such binding is urgently needed and unbound parts are deteriorating. Several new exchanges have been arranged, whereby the scope of usefulness of the Library has been increased.

5. Assistant General Secretary: Mr. M. K. Carpenter, who had acted as Assistant General Secretary from September 1st, 1919, resigned the post in August, 1920. Captain H. A. G. Jeffreys, O.B.E. was then appointed to the post, and took up the duties as from September 1st, 1920. Your Council desire to place on record its appreciation of the manner in which this gentleman has carried out the work.

6. Affiliation to the British Association: Formal application for affiliation of the South African Association for the Advancement of Science to the British Association was made on December 14th, 1920. The matter has been referred for consideration at the forthcoming meeting of the British Association at Edinburgh, in September, 1921.

7. Donations: The thanks of the Association are due to the Hon. the Minister for Education for the renewal of the grant of £250 towards the expenses of the publication of the Journal of the Association.

8. South Africa Medal and Grant, 1921: On the recommendation of the South Africa Medal Committee, consisting of Prof. J. Orr (Chairman), Sir J. C. Beattie, Prof. Crawford, Dr. Denison, Prof. Duerden, Prof. Fantham, Dr. Juritz, Dr. Mellor, Dr. Pole Evans, C.M.G., Dr. du Toit, Dr. Warren and Dr. Watkins-Pitchford, your Council has awarded the South Africa Medal, together with a grant of £50, to Sir Frederick Spencer Lister, M.R.C.S., L.R.C.P., Research Bacteriologist to the South African Institute for Medical Research. (See p. xxxii). The Secretary of the British Association has been notified of the award.

9. Associated Scientific and Technical Societies of South Africa: Prof. J. Orr and Mr. H. E. Wood have acted as the representatives of the Association on the Executive Committee of the Associated Scientific and Technical Societies of South Africa, of which your Association is a foundation society. The Associated Societies

are now in possession of a fine building, in which the meetings of the constituent societies are held. The monthly Council Meetings of the Association and the Annual Meeting of Witwatersrand members have been held here during the year. The building offers all club facilities to members of the Association.

10. THE NEW COUNCIL: On the basis of membership provided for in the Constitution of the Association, Section VI (d), the number of members of Council assigned for the representation of each centre during the ensuing twelve months should be distributed as follows:—

Cape Province—	
Cape Peninsula	6
East London	1
Kimberley	2
Kingwilliamstown	1
Port Elizabeth	2
Stellenbosch	2
Transvaal—	
Witwatersrand	15
Pretoria	4
Potchefstroom	1
Transvaal Outside	1
Orange Free State—	
Bloemfontein	2
Natal—	
Maritzburg	2
Durban	2
Natal Outside	1
Rhodesia—	
Salisbury	2
	44

REPORT OF THE HONORARY GENERAL TREASURER FOR THE YEAR ENDING MAY 31st, 1921.

The financial position of the Association is a serious one as, unfortunately, it has been for years. The audited balance sheet and statement of revenue and expenditure is presented along with this report.

At the end of last financial year the sum of £178 1s. 9d. owing on the Kingwilliamstown Journal had not been met. This amount has been paid out of this year's revenue, and appears as part of the Journal expenditure. To the actual Journal expenses of £740 3s. 9d., which includes the £178 1s. 9d. above-mentioned, a sum of £350 has been added as provision for printing the remainder of the Bulawāyo proceedings.

It is very unfortunate that through lack of funds to pay printing expenses the Council has been forced to withhold from the Endowment Fund £131 of life membership fees received during the last two years. This matter should be dealt with by the Council.

It is possible that unexpected donations or windfalls may benefit the Association during next year, as in certain past years; but in the absence of good fortune of this nature three things will be necessary to put the Association on a sound financial basis. First: an increased annual subscription. This has already been decided on, and from the beginning of next financial year the subscription will be 30s. instead of £1. Secondly: an augmented membership. The increase in the annual subscription will not of itself be sufficient to meet the claims on the Association's funds, unless there is a considerable increase in the membership list. The Council ought to decide whether any form of propaganda should be initiated with this object in view. Thirdly: a more prompt and regular payment of the subscriptions by the members. At the close of this financial year only 520, or 58 per cent., of the members have paid the annual subscription, and to this have to be added arrears collected from 33 members. This means a falling off of current and arrear subscriptions of £110, as compared with last year.

J. A. FOOTE,
Hon. General Treasurer.

June 25th, 1921.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

BALANCE SHEET AS AT 31st MAY, 1921.

LIABILITIES.

	£	s.	d.	£	s.	d.
To Sundry Creditors—						
Library Deposits	£3	0	0			
Joint Housing Scheme	11	6	3			
E. H. Adlington, Ltd.	61	9	7			
Hortor's, Ltd.	7	9	9			
Collins & List Bros.	0	9	6			
Subscriptions paid in advance	29	10	0			
Provision for estimated cost of printing JOURNAL	350	0	0			
Professor E. Warren—balance of 1920 Award	1	11	2			
Medal Fund—1921 Award ...	53	7	5			
				£518	3	8
,, Endowment Fund—						
Amount in hands of Trustees as per contra	1,573	0	0			
Add — Liability for Life Members not paid over to Trustees	131	0	0			
				1,704	0	0
,, South Africa Medal Fund				1,445	13	8
				£3,667	17	4

ASSETS.

	£	s.	d.	£	s.	d.
By Cash—						
At Bank	£40	0	0			
On hand	2	0	9			
				£42	0	9
,, Sundry Debtors				15	15	0
,, Medals on hand				7	6	11
,, Furniture				25	18	7
,, Trustees Endowment Fund—						
Balance at 31st May, 1920 ...	1,573	0	0			
Add—Interest accrued but not paid over	6	15	3			
				1,579	15	3
,, Trustees, South Africa Medal Fund—						
Amount of Fund	1,445	13	8			
				1,509	17	11
For Interest not yet paid over	64	4	3			
,, Revenue and Expenditure Account—						
Balance at 31st May, 1920 ...	159	9	6			
Add—Excess of Expenditure over Revenue for year to 31st May, 1921	327	13	5			
				487	2	11
				£3,667	17	4

We have examined the books and vouchers of the Association for the year ended 31st May, 1921, and certify that in our opinion the above Balance Sheet correctly sets forth the position of the affairs of the Association at the 31st May, 1921, according to the best of our information and the explanations given us and as shown by the Books.

Johannesburg,
24th June, 1921.

ALEX. AIKEN & CARTER, *Auditors.*

S.A. Medal Fund.—The amount of £64 4s. 3d. appearing as due by the Trustees has since been received, and the items £1 11s. 2d. and £53 7s. 5d. on the Liability side of the Balance Sheet have now been paid over.

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

REVENUE AND EXPENDITURE ACCOUNT FOR THE TWELVE MONTHS ENDED 31st MAY, 1921.

Dr.			
To Assistant General Secretary's Salary			£120 0 0
,, Typist's Salary			4 0 0
,, Rent			30 0 0
,, JOURNAL Expenses		£740 3 9	
Add—Provision for printing, remainder of 1920-21 proceedings as per Editor's estimate		350 0 0	
			1,090 3 9
Less—Sales and reprints	£98 12 5		
Donation, Union Department of Education ...	250 0 0		
		348 12 5	
			741 11 4
,, Printing and Stationery			22 12 9
,, Stamps and Telegrams			32 17 1
,, Sundry General Expenses			22 10 1
,, Grant under Rule IX.			6 12 0
,, Expenses Annual Meeting as per statement attached			25 5 1
,, Depreciation on Furniture			2 17 7
			£1,008 5 11

		Cr.
By Annual Subscriptions		£520 0 0
,, Arrear Subscriptions		33 0 0
,, Associates' Subscriptions		15 0 0
,, Interest on Endowment Fund ...		81 5 3
,, Interest on Savings Bank Deposit		4 16 3
,, Donations—		
Rand Mines, Ltd., towards cost of removal	£25 0 0	
Sundry	1 11 0	
		26 11 0
,, Balance, being excess of Expenditure over Revenue for year		327 13 5
		£1,008 5 11

Johannesburg,
24th June, 1921.

Examined and found correct.
ALEX. AIKEN & CARTER, *Auditors.*

THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

ANNUAL MEETING, BULAWAYO, 1920.

Dr.

To South African Railways—payment of railway fares of Members	£1,458 5 2	
,, South African Railways—payment for Secretary's fare ...	11 14 2	
		£1,469 19 4
,, Allocation of Grant from Minister of Mines—		
Institutional Membership Fee, Department of Mines	1 0 0	
Grants to Members on account of services rendered	29 0 0	
Secretary's expenses attending meeting	20 0 0	
		50 0 0
,, Stationery, Printing and Sundry Expenses		33 0 0
,, Bank Charges		1 9 6
		£1,554 8 10

Cr.

By Railway fares received from Members	£1,512 16 0	
Less—Fares refunded	35 12 6	
		£1,477 3 6
,, Grant from Minister of Mines and Industries		50 0 0
,, Exchange charges added to cheques		2 0 3
,, Balance transferred to Association's Revenue and Expenditure Account		25 5 1
		£1,554 8 10

SOUTH AFRICA MEDAL FUND ACCOUNT FOR THE YEAR ENDED 31st MAY, 1921.

To Award to Professor E. Warren, 1920	£51 11 2	By Balance of Fund at 31st May, 1920	1,500 14 6
,, Expenses in connection with Award	5 19 6	,, Balance of Interest received to 31/3/20	2 9 10
,, Award for 1921	53 7 5	,, Interest to 31/3/21	59 6 11
,, Expenses in connection with Award	5 19 6		
,, Balance, 31st May, 1921	1,445 13 8		
	£1,562 11 3		£1,562 11 3

ENDOWMENT FUND ACCOUNT FOR THE YEAR ENDED 31st MAY, 1921.

To Interest transferred to General Account	£81 5 3	By Balance at 31st May, 1920 ...	£1,670 0 0
,, Balance, 31st May, 1921	£1,704 0 0	,, Life Membership Subscriptions	34 0 0
		,, Interest on Investments	74 10 0
		,, Interest, Cape of Good Hope Savings Bank	6 15 3
	£1,785 5 3		£1,785 5 3

Note.—The Life Members' Subscriptions for 1920 and 1921, amounting to £131, have not yet been paid over to the Trustees of the Fund.

FOURTEENTH AWARD OF THE SOUTH AFRICAN MEDAL AND GRANT.

(Fund raised by Members of the British Association in Commemoration of their visit to South Africa in 1905.)

After the conclusion of the Presidental Address, in the Arthur Smith Hall of the Technical College, Durban, on Monday, July 11th, 1921, the President, Professor J. E. Duerden, presented the South Africa Medal, together with a grant of £50, to Sir Frederick Spencer Lister, Kt., M.R.C.S., L.R.C.P., Research Bacteriologist to the South African Institute for Medical Research, Johannesburg. In making the presentation, the President said:—

Sir Spencer Lister was educated at Barton School, Wisbech, England. He received his medical education at St. Bartholomew's Hospital, London. He obtained the qualification M.R.C.S., L.R.C.P. of the "Conjoint Board," in 1905. He has been Research Bacteriologist to the South African Institute for Medical Research since its opening in 1914.

Sir Spencer Lister has especially worked on the differentiation of the Pneumococci responsible for Lobar Pneumonia into many immunologically distinct groups, and the successful application of this discovery to the artificial production of immunity against that disease in human beings. The continuance of research upon lines which lead from Sir Spencer Lister's discoveries will, in all probability, result in a still further advancement of our knowledge of pneumococcal infections in man, and still further benefits of a practical character to the human race.

Amongst other publications, the following are the more important:—

"Specific Serological Reactions with Pneumococci from different Sources." December, 1913. *Publications of South African Institute for Medical Research.* Memoir No. 2.

"An Experimental Study of Prophylactic Inoculation against Pneumococcal Infection in the Rabbit and in Man." October, 1916. *Ibidem.* No. VIII.

"(1) Lysed Bacterial Serum. (2) Further Observations on Piantication. (3) A Note on Phagocytosis in the Absence of Serum." With A. R. Friel. April, 1917. *Ibidem.* No. IX.

"Prophylactic Inoculation of Man against Pneumococcal Infections, and more particularly against Lobar Pneumonia." November, 1917. *Ibidem.* No. X.

"Observations and Experimental Investigations in Epidemic Influenza." With Dr. E. Taylor. April 1919. *Ibidem.* No. XII.

"A Form of Crural Ulcer occurring in Natives due to a Specific infection." September, 1911. *Medical Journal of South Africa.* Vol. VII, pp. 25-26.

Previous Recipients.

1908. *Grahamstown.*—Arnold Theiler, C.M.G., V.M.D., Bacteriologist to the Transvaal Government, Pretoria.

1909. *Bloemfontein.*—Harry Bolus, D.Sc., F.L.S., of Sherwood Kenilworth, Cape Division.

1910. *Capetown.*—John Carruthers Beattie, D.Sc., F.R.S.E., Professor of Physics, South African College, Capetown.

1911. *Bulawayo.*—Louis Péringuey, D.Sc., F.E.S., F.Z.S., Director of the South African Museum, Capetown.

1912. *Port Elizabeth.*—Alexander William Roberts, D.Sc., F.R.A.S., F.R.S.E., of Lovedale Observatory, Cape Province.

1913. *Lourenço Marques.*—Arthur William Rogers, M.A., Sc.D., F.G.S., Assistant Director of the Union Geological Survey, Capetown.

1914. *Kimberley.*—Rudolph Marloth, M.A., Ph.D., Capetown.

1915. *Pretoria.*—Charles Pugsley Lounsbury, B.Sc., F.E.S., Chief of the Division of Entomology, Union Department of Agriculture, Pretoria.

1916. *Maritzburg.*—Thomas Robertson Sim, F.L.S., F.R.H.S., formerly Conservator of Forests for Natal.

1917. *Stellenbosch.*—John Dow Fisher Gilchrist, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Professor of Zoology, South African College, Capetown.

1918. *Johannesburg.*—Robert Thorburn Ayton Innes, F.R.S.E., F.R.A.S., Union Astronomer, Johannesburg.

1919. *Kingwilliamstown.*—James Moir, M.A., D.Sc., F.I.C., Government Mining Chemist, Johannesburg.

1920. *Bulawayo.*—Ernest Warren, D.Sc., Director of the Natal Museum and Professor of Zoology in Natal University College, Pietermaritzburg.

ASSOCIATION LIBRARY.

The following publications are filed at the Association's Room in the Public Library, Johannesburg.

General Science.

Royal Society of Edinburgh: Proceedings.
Royal Society of South Africa: Transactions.
Royal Society of South Australia: Memoirs.
Royal Society of South Australia: Transactions.
Royal Society of Victoria: Proceedings.
Royal Society of Canada: Proceedings and Transactions.
Royal Society of Tasmania: Papers and Proceedings.
Royal Society of Queensland: Proceedings.
Royal Dublin Society: Scientific Proceedings.
Royal Institution of Great Britain: Proceedings.
Royal Philosophical Society of Glasgow: Proceedings.
Royal Society of Arts: Journal.
Michigan Academy of Science: Reports.
Chicago Academy of Sciences:
    Bulletins.
    Special Publications.
Reale Academia dei Lincei, Rome: Atti.
Kungl. Svenska Vetenskapsakademien:
    Handlingar.
    Arsbok.
Koninklijke Akademie van Wetenschappen, Amsterdam:
    Proceedings of the Section of Sciences.
    Verhandelingen.
Real Academia de Ciencias de Madrid: Revista.
British Association for the Advancement of Science: Reports.
Australasian Association for the Advancement of Science: Reports.
American Association for the Advancement of Science: Proceedings.
Indian Association for the Cultivation of Science:
    Proceedings
    Reports.
    Bulletins.
Societâ Italiàna por il progresso della Scienze: Atti.
Association Française pour l'avancement des Sciences: Conférences.
Cambridge Philosophical Society:
    Transactions.
    Proceedings.

Manchester Literary and Philosophical Society: Memoirs and Proceedings.
American Philosophical Society: Proceedings.
University of California:
 Bulletins.
 Memoirs.
University of Virginia: Philosophical Society Bulletins.
Tôhoku Imperial University: Science Reports.
New York Academy of Sciences: Annals.
American Academy of Arts and Sciences: Transactions.
Connecticut Academy of Arts and Sciences: Proceedings.
Meddelanden fran K. Vetenskapsakademien Nobelinstitut.
California Academy of Sciences: Proceedings.
Academy of Science of St. Louis: Transactions.
Academy of Natural Sciences of Philadelphia: Prceedings.
American Journal of Science.
Ohio Journal of Science.
Nova Scotian Institute of Science: Proceedings and Transactions.
Revue Générale des Sciences.
Archives Néerlandaises des sciences exactes et naturelles.
Annaes scientificos da Academia polytechnica do Porto.
Rhodesia Scientific Association:
 Annual Reports
 Proceedings.
Société de physique et d'histoire naturelle de Genève:
 Memoirs.
 Comptes rendus.
Det Kongelige Norske Videnskapers Selskaps Skrifter.
Kongelige Danske Videnskabernes Selskab: Oversigt.
Vierteljahrsschrift der naturforschenden Gesellschaft, Zurich.
Imperial Institute: Bulletins.
New Zealand Institute: Transactions and Proceedings.
Annual Report of the Smithsonian Institution (United States National Museum).
South African Museum:
 Annals.
 Annual Reports.
Transvaal Museum: Annuals.
Natal Museum: Annals.
Queensland Museum:
 Annals.
 Memoirs.
Field Museum of Natural History Publications.
University of Pennsylvania Museum Journal.
Public Museum of Milwaukee: Bulletins.
Albany Museum:
 Annual Reports.
 Records.
Knowledge.
Science.
Franklin Institute: Journal.
University of Minnesota: Current Problems.

Chemistry, Metallurgy and Geology.

Chemical, Metallurgical and Mining Society of South Africa: Journal.
Kungl. Svenska Vetenskapsakademien: Arkiv för Kemi, Mineralogi, och Geologi.
Geological Society of South Africa: Transactions.
Geological Society of Tokyo: Journal.
Geological Survey of New South Wales: Reports.
 Memoirs.
 Mineral Resources.
Geological Institution of the University of Upsala: Bulletins.
Geological Society, London: Abstracts of Proceedings.
Bulletins of the Wyoming State Geologist.

United States Geological Survey:
- Annual
- Mineral Resources.
- Bulletins.
- Monographs.
- Professional Papers.

Florida State Geological Survey: Annual Reports.
Servico geologico e mineralogico do Brasil: Monographias.
Union of South Africa Mines Department: Annual Reports.
Canada Department of Mines:
- Museum Bulletins.
- Memoirs of the Geological Survey.
- Reports.

New South Wales Department of Mines: Annual Reports.
The Mineralogical Magazine.
Egyptian Ministry of Finance: Geological Reports.
Geological Survey of Western Australia:
- Annual Progress Reports.
- Bulletins.

Journal of Industrial and Engineering Chemistry.
Journal of Chemical Technology.
The Chemical News.
University of Minnesota: Studies in Chemistry.
South African Association of Analytical Chemists: Proceedings.

Meteorology.

Royal Meteorological Society: Quarterly Journal.
Mount Weather Observatory: Bulletins.
Observatorio Campos Rodrigues:
- Relatorio.
- Resumo mensal.

Egyptian Ministry of Finance: Meteorological Reports.

Agriculture.

Regia Scuola superiore agricoltura di Portici: Annali.
International Institute of Agriculture, Rome:
- International Crop Report and Agricultural Statistics.
- International Review of the Science and Practice of Agriculture.
- Documentary Leaflets.
- Statistical Notes on the Cereals.

Massachusetts Agricultural Experiment Station:
- Annual Reports.
- Bulletins.

Maine Agricultural Experiment Station: Annual Reports.
Agricultural Gazette of New South Wales.
Department of Agriculture, New South Wales: Science Buildings.
United States Department of Agriculture:
- Experiment Station Record.
- Year Book.

New York State College of Agriculture and Experiment Station:
- Annual Reports.

Journal of Agricultural Research.
Rhodesia Agricultural Journal.
Revista de Agricultura, Comercio y Trabajo, Cuba.
Bulletin Agricole de l'Algerie-Tunisie-Maroc.
Station agronomique de la Guadeloupe: Bulletin.
Union of South Africa Agricultural Journal.

Biology and Physiology.

Bulletin de la Société Imperiale des naturalistes de Moscou
Kungl. Svenska Vetenskapsakademien:
- Arkiv för Botanik.
- Arkiv för Zoologi.

Journal of the Linnean Society, Botany.

Bulletin of the Wisconsin Natural History Society.
The Medical Journal of South Africa.
University of California: Publications in Botany.
Linnean Society of New South Wales: Proceedings.
Missouri Botanical Garden:
Annual Reports.
Annals.
Bolus Herbarium: Annals.
Smithsonian Institution (United States National Museum): Contributions from the United States National Herbarium.
Royal Botanic Gardens, Kew: Bulletins.
Union of South Africa: Reports of the Director of Veterinary Research.
University of Michigan, Museum of Zoology:
Miscellaneous Publications.
Occasional Papers.
Lloyd Library:
Bibliographical contributions.
Mycological Notes.
South African Biological Society: Bulletins.

Entomology.

Bulletin of Entomological Research.
Review of Applied Entomology.

Bacteriology.

Abstracts of Bacteriology.

Astronomy, Mathematics and Physics.

Royal Astronomical Society:
Memoirs.
Monthly Notices.
Journal of the Royal Astronomical Society of Canada.
Harvard College Astronomical Observatory:
Circulars.
Annals.
Annual Reports.
Leyden Sterrenwacht: Annalen.
Union Observatory Circulars.
Cape Observatory.
Annals.
Reports.
Cape Astrographic Zones.
Observatoire Royal de Belgique; annuaire astronomique.
Khedival Observatory, Helwan, Egypt: Bulletins.
Kodaikanal Observatory: Bulletins.
Kodiakanal and Madras Observatories: Annual Reports.
British Astronomical Association:
Journal.
Memoirs.
Lick Observatory: Bulletins.
Nizamiah Observatory: Reports.
Astronomical Society of India:
Journal.
Monthly Notices.
United States Naval Observatory Publications.
American Ephemeris and Nautical Almanac.
Western Australian Astronomical Society: Proceedings.
Kungl. Svenska Vetenskapsakademien: Arkiv för Matematik, Astronomi och Fysik.
London Mathematical Society: Proceedings.
Tôhoku Mathematical Journal.
National Physical Laboratory, Middlesex:
Collected Researches.
Reports.

University of Minnesota: Studies in the Physical Sciences and Mathematics.
Universidad Nacional de la Plata: Contribucion al estudio de las Ciencias fisicas y matematicas.
Physical Society of London: Proceedings.

Educational, Political Economy and Sociology.

United Empire.
South Africa.
Ohio State University Bulletin.
International Institute of Agriculture, Rome: International Review of Agricultural Economics.
Royal Dublin Society: Economic Proceedings.
Athenæum subject index to Periodicals.
Municipal Journal of South Africa.
University of Minnesota:
  Studies in Economics.
  Studies in Public Health.
  Studies in the Social Sciences.

Geography, Oceanography and Hydrography.

Società Italiana per il progresso delle Scienze: Comitato talassografico:
  Bolletinos.
  Memorias.
The Geographical Journal.
The Geographical Review.
United States Geological Survey: Water Supply Papers.
Egyptian Ministry of Finance: Survey Department Papers.
Instituto di geografia fisica e vulcanologica della R. Universita di Catania: Pubblicazioni.
United States Department of Commerce, Coast and Geodetic Survey.
  Special Publications.
  Annual Reports.

Engineering.

Proceedings of the American Institute of Electrical Engineers.
Journal of the South African Institution of Engineers.
Transactions of the South African Institute of Electrical Engineers.
South African Society of Civil Engineers: Proceedings.
South African Engineering.
University of Minnesota: Studies in Engineering.

Technology.

University of Minnesota: Abridgments of Specifications.
The Illustrated Official Patents Journal.
South African Journal of Industries.

Anthropology and Ethnology.

Journal of the African Society.
University of Minnesota: Studies in Language and Literature.

Archæology.

Bulletins of the Archæological Survey of Nubia.

OFFICERS AND COUNCIL, 1921-22.

Honorary President:
HIS MAJESTY THE KING.

President:
A. W. ROGERS, Sc.D., F.R.S.

Ex-President:
Prof. J. E. DUERDEN, M.Sc., Ph.D.

Vice-Presidents:

Prof. A. BROWN, M.A., B.Sc.
Prof. R. B. DENISON, D.Sc., Ph.D.
E. FARRAR.
Prof. T. M. FORSYTH, M.A., D.Phil.

Hon. General Secretaries:

H. E. WOOD, M.Sc.,
Union Observatory,
Johannesburg.

C. F. JURITZ, M.A., D.Sc.,
Division of Chemistry,
Cape Town.

Hon. General Treasurer:

JAMES GRAY, F.I.C.,
P.O. Box 5254.
Johannesburg.

Hon. Editor of Publications:

Prof. H. B. FANTHAM, M.A., D.Sc.,
The University,
Johannesburg.

Hon. Librarian:

ANNIE PORTER, D.Sc.,
S.A. Institute for
Medical Research,
Johannesburg.

Assistant General Secretary:

H. A. G. JEFFREYS, O.B.E.,
P.O. Box 6894,
Johannesburg.
(Telegraphic Address: "Science.")

Ordinary Members of Conncil:

I.—CAPE PROVINCE.

Cape Peninsula.

Prof. L. CRAWFORD, M.A., D.Sc.
Rev. W. FLINT, D.D.
J. LUNT, D.Sc.
C. W. MALLY, M.Sc.
C. GRAHAM BOTHA.
Prof. R. LESLIE, M.A.
Prof. J. ORR, O.B.E., B.Sc., M.I.C.E.
A. M. ROBB, M.A.
Prof. J. A. WILKINSON, M.A.

Kimberley.

Miss M. WILMAN.

Kingwilliamstown.

E. B. DWYER, B.A.

Port Elizabeth.

F. W. FITZSIMONS, F.Z.S.
Rev. J. R. L. KINGON, M.A., D.Sc.

Stellenbosch.

Prof. E. J. GODDARD, B.A., D.Sc.
Miss ALTA JOHNSON, Ph.B.

II.—TRANSVAAL.

R. DES CLAYES.
J. A. FOOTE, F.G.S.,
R. T. A. INNES, F.R.A.S.
W. INGHAM, M.I.C.E., M.I.M.E
Sir SPENCER LISTER, M.R.C.S., L.R.C.P.
J. McCRAE, Ph.D., F.I.C.
E. T. MELLOR, D.Sc.
J. MOIR, M.A., D.Sc.
Advocate G. T. MORICE, K.C., B.A.
A. J. ORENSTEIN, C.M.G., M.D.

Pretoria.

P. J. DU TOIT, B.A., Ph.D., Dr. Med. Vet.
Prof. P. G. GUNDRY, B.Sc., Ph.D.
A. K. HAAGNER.
E. P. PHILLIPS, M.A., D.Sc.

III.—ORANGE FREE STATE.

Bloemfontein.

Prof. M. M. RINDL, Ing.D.

IV.—NATAL.

Durban.

E. C. CHUBB, F.Z.S.
B. M. NARBETH, B.Sc.

Pietermaritzburg.

Prof. J. W. BEWS, M.A., D.Sc.
Prof. E. WARREN, D.Sc.

V.—RHODESIA.

Bulawayo.

Rev. E. GOETZ, S.J., M.A.

Salisbury.

H. B. MAUFE, B.A.

VI.—MOZAMBIQUE.

S. SERUYA.

Trustees:

Endowment Fund.

Principal Sir J. C. BEATTIE, D.Sc.
J. W. JAGGER, F.S.S., M.L.A.
W. RUNCIMAN, M.L.A.

S.A. Medal Fund.

J. DE V. ROOS, B.A., LL.B.
W. THOMSON, M.A., B.Sc., LL.D.
W. J. VILJOEN, M.A., Ph.D.

SOCIAL ANTHROPOLOGY IN SOUTH AFRICA: PROBLEMS OF RACE AND NATIONALITY.

BY

J. E. Duerden, M.Sc., Ph.D., A.R.C.Sc., F.Z.S.,
President,

Professor of Zoology, Rhodes University College, Grahamstown; Officer-in-Charge, Ostrich Investigations, Grootfontein School of Agriculture, Middelburg, C.P.

Presidential Address delivered July 11, 1921.

Contents.

Scientific Effort in South Africa.

The South African Association for the Advancement of Science was founded in 1903 upon the model of the British Association, which has existed since 1831, and which in 1905 paid a visit to South Africa. During the past year it has been my good fortune to attend the meetings of the parent Association in Cardiff. Formerly, at the annual gatherings, it was customary for the President to pass in review all the recent advances in the different sciences, and to indicate their general trends and needs. In these latter days, with the vast array of scientific workers on every hand, this is no longer possible, even for the most omniscient of Presidents; indeed, it is questionable whether he can survey the whole field in his own subject. All the more difficult is this in South Africa with our restricted means of knowing what is being accomplished, both within the Union and overseas. I desire, however, to dwell for a few moments upon the progress in general recognition of Science in South Africa, particularly as represented by developments in higher education and in the encouragement of research.

By the Act of Union in 1910 the four Provinces in South Africa were consolidated, and the country assumed a unified control of all its internal affairs where hitherto there had been diversity. With Union has come strength, and the ten years

which have elapsed reveal that the country is making vigorous efforts to rise to its responsibilities, and to build upon the sure foundation of education and investigation. Everywhere we see an earnest endeavour to supply its own requirements in trained men and to provide them with opportunities, and the principle of South Africa for the South African is applied with more and more success. The efforts in the direction of university development, of agricultural progress, and of technical application are particularly encouraging. Ten years ago it was barely possible to procure a South African trained scholar for the higher positions in elementary education, much less for university appointments. Now in all directions men are being supplied by our universities, fully trained for these careers; where in 1910 there were 1,171 university students, last year there were 2,947, nearly three times the number, with a corresponding increase in State expenditure. Four vigorous universities exist where a few years ago there was only one, and others of the federated University Colleges are more than dreaming of separate Charters. We congratulate Johannesburg, which has procured its Charter so recently, and wish it every success. In place of relying wholly on oversea institutions for training in medicine, two of the universities are for the first time preparing students for the complete medical degree; while investigational work at the Institute for Medical Research in Johannesburg ranks high in comparison with that in similar institutions abroad.

The provision of veterinary officers is of first importance for South Africa, with its innumerable and baffling stock diseases. Within the past year a scheme has been initiated for a training in veterinary science which, under Sir Arnold Theiler, a past President of this Association, will be on a foundation well in advance of that in any other part of the world, as is the Onderstepoort Laboratory with which it will be associated. For many years South African youths of promise have been sent abroad by the Government to study the agricultural sciences in the universities of Europe and America, and have returned to occupy positions as lecturers in the various Schools of Agriculture, and as agricultural advisers and investigators. The universities have again risen to the occasion, and two of them have now established Faculties in Agriculture which provide degree courses, and will soon supply South Africa with her own trained experts. Two or more of the five Schools of Agriculture are likewise making laudable efforts to advance their courses of instruction from a school standard to that of a university. It is by no means contended that the training to be obtained in South Africa will supply for some time that wide experience and culture obtainable from the older universities overseas, but we are earnestly endeavouring to meet the educational requirements of the country step by step with its natural growth. There are few youths of ability who are not given the opportunity to scale the educational ladder.

The Government throughout has shown a high recognition of the value of scientific research in all its industrial and economic

applications. The Technical College in which we are gathered is one of the tangible evidences of this. I congratulate you upon its proposed affiliation with the University College at Pietermaritzburg, holding, as I do, that the association with university aims and standards will tend to the enrichment of its own ideals and attainments. The many Divisions of the Union Department of Agriculture have research as their primary aim, stimulated thereto by a succession of clear-sighted Ministers and Secretaries. We have also an official Geological Survey, a Soil Survey, a Fishery Survey, a Botanical Survey, and an attempt towards a Zoological Survey. As regards industries we have an Advisory Board with a Scientific and Technical Committee, the latter composed of men of science, charged to "investigate and report to the Government on questions affecting the economic, scientific, and technical aspects of the utilisation of raw materials available in South Africa, and collect data and information in regard to the resources of the Union, which as yet are largely undeveloped." South Africa is a new country, with problems in every direction, and it is not slow in its appeal to the man of science to assist in their solution. Probably in no other part of the world is the ordinary man of science afforded so many opportunities for leaving his mark upon his country; moreover, the work can never end, for each advance brings with it its own fresh difficulties.

I say all this for a purpose. I wish to impress upon ourselves as members of the South African Association for the Advancement of Science that as the requirements of our country are great, so is the responsibility. As men of science we are to show what science can contribute. The needs and opportunities should render us enthusiastic and devoted workers, fully determined to justify the high trust reposed in us, that of furthering our country's welfare.

Social Anthropology.

The progress of scientific effort in South Africa which I have briefly sketched will suffice to show that for the time being we have passed the formative stage in the matter of institutional and departmental organisation, and can now settle down to the more and more complete realisation of the purpose of it all. Apart from that of education, the directions outlined are concerned with the material progress of the country, and I have no desire to minimise the importance of this; but it is not all inclusive. I now wish to turn to a subject which more directly concerns ourselves as human beings, particularly our inter-relationships among the constituent peoples of South Africa; for, after all, in Pope's words, "The proper study of mankind is man." I hope to show that in matters of human relationship there is in South Africa just as much need for the man of science as there is in material things, and that results just as great, if not greater, are to be expected.

The subject of Anthropology is comprised under Section E of our Association, and it has ever been a strong Section in South Africa, innumerable problems presenting themselves in connection with our many native tribes. It is not unlikely that, had he lived,

the late Mr. Maurice Evans, a citizen of Durban, and author of "Black and White in South-East Africa" and other works, would have occupied the President's chair in which I now find myself, and would have discoursed to you from the mellow experience of his life's study of native problems. It is partly the knowledge of your interest in these matters which has influenced me in the choice of my subject. Anthropology is indeed an all-embracing science, taking man in all his aspects; ethnological, archaeological, historical and psychological. Within recent years it has also come to include man as a social being, that is, in his relationship to others as a member of society; and we have the sub-division of Social Anthropology or Sociology. The importance of studying man from this last aspect was strongly urged by Professor Karl Pearson in his Presidential Address before Section H of the British Association last year, and I confess that I have been deeply influenced by his remarks, believing that in a very special sense they apply to our conditions in South Africa.

Anthropological studies in South Africa have hitherto been largely confined to the description of the habits, customs and beliefs of the natives and accounts of their weapons, implements and drawings, as well as of their bodily characteristics. Excellent work has been done, much of which appears in the Reports of the Association and in the publications of our various Museums. Among more recent contributors the following names stand out prominently: Peringuey, Bleek, Stow, Junod, Miss Lloyd and Miss Tucker. Professor Karl Pearson, as Director of the Galton Laboratory, London, has for a long period taken the lead among anthropologists in the application of statistical and biometrical methods to human studies. Impressed, however, with the world's great problems of human inter-relationships at the present time, he now writes: "I have already tried to indicate that the problems before us to-day, the grave problems that are pressing on us with regard to the future, cannot be solved by old materials and by old methods. We have to make anthropology a wise counsellor of the State, and this means a counsellor in political matters, in commercial matters, and in social matters." And again: "The psycho-physical and the psycho-physiological characters are of far greater weight in the struggle of the nations to-day than the superficial measurement of man's body." He then proceeds to show from correspondence and manifestoes emanating from anthropologists in Germany that the professors there are disposed to place the blame for the late disasters of their country largely upon an imperfect knowledge of anthropology. Thus from one manifesto he culls the following: "The sad results of our foreign policy, the collapse of all our calculations as to national frames of mind, were based in no small degree on ethnographic ignorance." From it all Karl Pearson sums up as follows: "I think that you will agree with me that rightly or wrongly there is a conviction spreading in Germany that the war arose and that the war was lost because a nation of professed thinkers had studied all sciences, but had omitted to study aptly the science of man. . .

If the science of man stood where we may hope it will stand in the dim and distant future, man would from the past and the surrounding present have some grasp of the future evolution, and so have a greater chance of guiding its controllable factors."

I have quoted freely from Professor Karl Pearson because he presents a more enlarged view of anthropology which, as I have said, is particularly applicable to us in South Africa, the view that anthropological studies should contribute to the upbuilding of the State by offering a scientific understanding of the peoples within it.

From the broad aspect of the British Empire, Dr. Arthur Keith is equally insistent upon the importance of the proper study of Anthropology. In a lecture delivered in Oxford in 1919 he remarks: "The problems of Race and Nationality then are by no means new. The far-flung lines of the British Empire and the mobilisation of our popular spirit by means of the press and propaganda have compelled our statesmen, historians, publicists, psychologists, and anthropologists to re-examine the nature of the forces which lie behind racial movements and national agitations. Of the importance of a right understanding of the nature of these forces for the future maintenance and development of the British Empire there cannot be any question."

I rejoice to think that we are already at the beginning of this newer study of mankind in South Africa, and that before long we shall be making advances in the direction so strongly advocated by Professor Karl Pearson and Dr. Keith. Only within the past two or three months a Professorship of Social Anthropology has been founded at the University of Capetown, and Mr. A. R. Brown has been appointed. I believe it is the first of its kind in the world, and we may well congratulate the University on the appointment. I was in Cambridge when it was first announced, and the anthropologists there, Dr. A. C. Haddon and Dr. W. H. R. Rivers, were keenly interested in its possibilities for South Africa, as was also Professor Henry Balfour, Oxford, well known to many workers here. Again, last year a Native Affairs Commission was appointed as advisory to the Government, two of its members at any rate, Senator Dr. A. W. Roberts and Dr. C. T. Loram, being men of science and interested in anthropological investigation, in both its social and educational aspects. These I regard as happy auguries for the study of Social Anthropology in South Africa, and I trace them to the initiative and wise statesmanship of General Smuts, Premier and Minister of Native Affairs, an outstanding figure among the statesmen of the world, a son of whom South Africa is justly proud. His speech in introducing the Bill to establish the Native Affairs Commission revealed a marvellous grasp of native problems, and a sympathetic determination that the country should do the right thing by the native. In this attitude he follows another great South African, the late Cecil John Rhodes, who in his Glen Grey Act (1894) initiated a sympathetic and, at the same time, a sound policy in native administration.

Complexity of Sociological Problems in South Africa.

South Africa is a country excelling in sociological problems, racial and inter-racial, national and inter-national. No other country in the world has so many distinct races and nations settled within its borders, and at such diverse stages of social evolution. At the one extreme are the survivors of the earliest historic inhabitants, the *Bushmen*, who are among the lowest of all people in civilisation, and representative of the primitive communistic hunting stage of human development; we have also the lowly *Hottentots*, still in the pastoral or cattle-rearing phase of industrial evolution. The *Bantus*, whether as Xosas, Zulus, Swazis, Basutos, Bechuanas, or other of their tribal sub-divisions, comprise about two-thirds of our population of seven millions, and industrially they have attained only a primitive agricultural stage. These are all classed as natives, though the Bantu immigrated from the north only three or four hundred years ago. The Bushmen and the Hottentots are now so few in number and so intermingled with the others as to call for no special consideration; our great concern is with the four million Bantu, whether segregated in Reserves or freely mingling with the white.

Coloured peoples, in the narrower meaning of the term, numbered 678,146 according to the census of 1911. At the extreme Southern border are the so-called Malays, comprising representatives of the Malay Archipelago, the East Indies, and the East Coast of tropical Africa, largely the descendants of imported slaves. In Natal you have your own special problem of the Indian, brought here under the indentured labour system. Everywhere, but particularly around the urban centres, are the coloured Eur-Africans, a varied admixture largely of European and native blood. Finally, at the highest extreme of civilisation, are the Nordic whites, mainly representative of the two European nations, British and Dutch, but mingled with French; including also communities of Germans around King William's Town, and now in the South-West Protectorate as well.

With the passing of the Act of Union in 1910 the die has been cast for South Africa and, so far as can be humanly predicted, it will in the main retain its present geographical and ethnographical features for a long time to come. We are all to live together, confined within one Union—British, Dutch, Bantu, Asiatic, Eur-African, and all the smaller elements which make up our population. We are to be one country, one people, all South Africans, directly subservient to one Government, and also with the status of partnership in the British Commonwealth of Nations. The various constituents have come together, each with its own traditions and with its own racial consciousness. We intermingle with difficulty and blend with reluctance; yet we have to go through the melting pot, and can only speculate as to how we shall emerge. It is an inspiring reflection, this building up of a new nation from such heterogeneous elements, and its successful realisation will demand the best efforts of all.

Fortunately we have for the most part come together voluntarily, with practically equal rights, or absence of rights, of occupancy. The members of no group can sustain a priority claim of ownership to the country, nor has there been much aggressive subjugation by conquest. The Bushmen alone are the original inhabitants, the Hottentots following later. But as communities both of these have succumbed before later arrivals, their primitive nature and mode of life rendering them incapable of adaptation to the new conditions. The salient features of the later introductions are well known and only call for the briefest summary. The Portuguese first discovered the Cape at the end of the fifteenth century, and in the sixteenth and seventeenth centuries it was visited by Dutch and English vessels on their way to the East Indies, the first Dutch occupancy under Governor Jan Van Riebeek taking place in 1652. Malays were first imported as slaves in 1654 and Negroes from the Guinea Coast in 1658. One hundred and sixty-four refugee Huguenots arrived between 1688 and 1700. The census of the Dutch centenary of Occupation in 1752 showed but 5,510 Europeans and 6,279 slaves. The British took the Cape in 1795, restored it in 1803, and finally occupied it in 1806. In 1820 nearly 4,000 British settlers arrived and spread over the Eastern Province. Their centenary we in Grahamstown have just been worthily celebrating. Emancipation of slaves took place in 1834. Consequent upon the Great Trek, the Boers established a republic in Natal in 1839 and Pietermaritzburg was founded; they partly trekked out again in 1842, and Natal remained largely British. Indian labour was first introduced in 1858, and in 1911 there were 133,439 Asiatics to 98,114 Europeans. At first the few Dutch remained around Cape Town, but gradually numbers spread northwards and eastwards, their extension taking the form of organised treks in the thirties, and later the founding of the Orange Free State and the Transvaal. Everywhere Dutch and English came into contact with the various Bantu tribes who had come down from the north in successive waves, and were living in a state of inter-tribal warfare. Numerous conflicts and much negotiation resulted from the clash, extending almost to the present day, and the names of many distinguished tribal leaders emerge—Tshaka, Dingaan, Panda, Cetewayo, Moshesh, Moselekatse, Lobengula, Dinizulu and Kama. Within the present century the numerous conflicting elements may be held to have settled down in peaceable occupation of the country, and the Act of Union has consolidated them for good and all.

The vastness of the sociological problems presented by this unique admixture of people must appeal to all. We may well ask how such a varied assemblage of races and nations can live together in harmony and good-will, each group for the good of itself and for the good of the whole. For in these days of easy communication no part of a population can live unto itself; there are inter-relationships which can not be avoided. It can hardly be expected that peoples differing racially and at different stages of social evolution can live side by side with the same harmony as obtains

among people of the same nation; there is more that calls for mutual forbearance and tolerance, and a manifestation of the spirit of sympathy. Our peculiar difficulties are clearly appreciated by anthropologists elsewhere. Thus Dr. Keith in his paper, "Nationality and Race," remarks: "In South Africa we find problems of race and nationality in a more acute and tangled form than anywhere else in the world." Questions will arise as to how far we are all to be moulded into a semblance of one another, or how far we shall retain our original racial and national distinctions. Moreover, human society is never stationary. It is moved by different principles and ideals at different times; the relationships are for ever changing, and no present attainment is immutable. Hence the need for the continued study of the psychological attributes as well as of the material welfare of our peoples, and for their guidance in the light of the historic past and of accepted sociological principles. Much of the study calls for that personal detachment and freedom which we hold to be one of the prerogatives of the man of science. Though it may not be usual to regard these problems as subjects of scientific enquiry, yet in the course of my address I hope to show the urgent need for the methods which science can apply, and that it is fitting that questions of this nature should receive the attention of the Association. We do not encroach upon the stormy preserves of the politician. We assist by the elaboration of facts and principles for him to apply in practice, among the varied and often divergent interests of the whole population; and at the same time may help in the building up of correct ideals for the public.

It may well be asked what claim a zoologist has to speak on human affairs, seeing that in general he limits his work to the lower animals. He is, however, accustomed to study his animals in their entirety—their development, their evolution, and their constitution, as well as their activities. He is accustomed to account for what a creature does, and he is under no delusions; he knows that with a certain constitution an animal can perform only certain actions under certain conditions. To him the real nature of the animal is for all practical purposes unchangeable from generation to generation, though it may be largely influenced by its environment. The attitude of mind engendered by studies of this kind may, I venture to think, be at times applied with advantage to man himself; moreover, an intimate personal experience of the Negro and other coloured races, gained by residence in the West Indies, the Northern and Southern States of America, and in the Islands of the Pacific, may well be of assistance as supplementary to that which one acquires in South Africa.

Change of Attitude Towards the Native.

Africa is often proclaimed as the "Black Man's Continent." Certainly the Bantu is with us at every turn in South Africa, but historically we Europeans have just as much right of occupancy as he has, for, as I have shown, we are all recent immigrants who have dispossessed the diminutive, unadaptive Bushman. Moreover, there is every reason to expect that both white and black

are here to remain, and are settled along the lines which will be preserved for a long time to come. It has taken practically all the period since the Dutch occupancy in 1652 to effect this settlement, and in the process racial strife has at times been aroused. Enmity engendered by warfare has now happily ceased, and any present manifestations of discontent are fundamentally sociological; they are such as might well be expected to arise in the mutual relationships of a superior race and an inferior one, the latter outnumbering the former four or five times. Harsh, unsympathetic treatment and exploitation have also been meted out by the white to the black under the struggles incidental to the founding of a new country. But, however unjustifiable, South Africa has in this no more than followed the treatment which during the past centuries has almost everywhere characterised the relationships between inferior and superior races. This general attitude was manifested in its extreme form in slavery, an institution which until last century was held to be justifiable by all countries and all peoples. South Africa, however, never enslaved its own natives.

Within the present century more particularly, any harsh, suppressive attitude towards the lower races has largely passed away in South Africa, to be replaced by one in which just and humane considerations are in the ascendant. In spirit, at any rate, the attitude is far removed from that which Lord Bryce described in 1897, in his "Impressions of South Africa." The change of ideals has been gradual as regards the mass of the people, and has perhaps lagged behind in the Transvaal and the Orange Free State, as compared with the Cape Province. To the missionaries must be given the credit of leading the way, though in their early doctrine of brotherhood and equality they displayed no sound appreciation of the real fundamental differences of race and all that they imply. I wish to lay stress upon this change of attitude of the white towards the black in South Africa. It is correctly exemplified by the public utterances of practically all our statesmen, notably General Smuts and before him the late General Botha, by the regard paid by the Municipalities to the welfare of the natives in Locations, as disclosed by the Municipal Congress this year in Cape Town; by the appointment of the Commission to guide and advise on Native Affairs, and by the establishment of a University Professorship of Social Anthropology to study the question with all the resources which science can command. It is this change of attitude and the obligations it entails which introduce so many new problems. How shall we best apply our sympathetic ideals in practice, and what is likely to be the result in the future? We can do just as much harm as good if we do not proceed on right lines, having due regard to innate racial peculiarities and to the interests of all concerned.

In a country which has undergone so many internal disturbances as South Africa, legislative efforts on behalf of the native may well lag behind desire; but in all directions an earnest effort is now manifest to cope with them. We have, however, to

admit that intimate contact of the black and white, and the growth of education, conduce to comparison of their relative conditions which, on the part of the inferior race, may well be expected to express itself in discontent. Recent native disturbances like those in Port Elizabeth, Lovedale, and Bullhoek are, however, local in their origin and bearing, and do not represent any wide, deep-seated dissatisfaction, though this is usually the interpretation given abroad. Education is at first a revealer of disparity and engenders grievances, as we see in all parts of the world at the present time; but it can not be held back, and in the end it makes for solidarity.

The change of attitude towards the native in South Africa is but a part of a world movement in the sympathetic interrelationships of peoples. Discussing the new modern organisation of States in which social classes still persist, but in which all caste systems are abolished and all the members of the nation are regarded as being by nature free and equal, Mr. W. McDougall, in "The Group Mind," remarks: "The change is very striking also as regards the attitude of the citizens of one State towards those of any other and towards even the members of savage and barbarous communities. We no longer regard ourselves as devoid of all obligations towards such persons. Rather we tend to treat them as having equal rights with ourselves, and as having equal claims with our fellow-citizens upon our considerate feeling and conduct towards them." And again, "It would be easy for the European nations to exterminate the black people of Africa, and to possess themselves of all their lands. But public opinion will not allow this; it insists upon our moral obligations towards such peoples, that we are bound to try to help them to survive and to raise themselves to our level of culture."

Aversion Between White and Black.

To appreciate some of our racial difficulties it is necessary to dwell upon the psychological aversion which so often characterises the relationships of black and white. Many attempts have been made to analyse the feeling. The problem is one of some complexity in which a number of factors are concerned, instinctive and acquired. Perhaps some assistance towards an understanding may be gained from a survey of the conditions under which it is and is not manifested. We may admit that a primitive instinctive antipathy tends to exist among all peoples, between clans, tribes, nations, and races, which is greater the more divergent are the physical, mental, and social natures. It is a part of the universal, tribal or clannish spirit, having isolation as a common factor which, according to Dr. Keith, "is an essential part of Nature's evolutionary machinery. It was in these isolated cradles of primitive mankind that Nature nursed and reared new races."

But this primary spirit of aversion is usually overcome as peoples become acquainted, especially when the interests are neither opposing nor competitive. Thus when brought together all white nationalities associate on terms of equality, as is seen on a grand scale in the United States. Though not blending, whites

generally associate on an equality with the intellectual brown Hindu and the yellow Chinese and Japanese, thereby showing that colour and difference of race by no means necessarily engender aversion. Negroes visiting Europe and moving among whites who have no experience of the black in his own country, are received and treated with every mark of regard and equality, and admitted to the social stratum for which their education and training befit them. From this we may conclude that on the part of the modern white the aversion towards the black has not a primary instinctive foundation, as is sometimes held. It is something which is engendered on acquaintance with him on intimate terms or *en masse*, and is observed to come over every European on first settling in South Africa.

But even on intimate terms in South Africa no aversion is displayed between white and black so long as certain relationships are maintained. In domestic service the native is treated with practically the same consideration as obtains in the corresponding relationship between master or mistress and servant in Europe. The regard in which Zulu servants are held in Natal and Johannesburg may be instanced. On the farms it is my experience that the native receives just and considerate treatment, with due regard to his self-esteem; also in offices, in places of business, and in industrial occupations he is usually treated as considerately as are white persons of similar status in Europe. Cases of harsh and unreasonable treatment can always be adduced; but these are not racial in their significance. They are merely illustrative of the treatment met with everywhere from a certain class of employer towards his dependents, or from a superior towards an inferior. On the part of the better type of white people in South Africa it can with full justification be claimed that nothing but a just and considerate relationship obtains towards the native, so long as the latter maintains a defined position, and that no feeling of antipathy, much less of hatred, exists.

It is when the native attempts to assume an attitude or position of equality with the white that antipathy is engendered and also manifested. Thus white and black domestic servants will not work together on terms of equality, nor will the white and the black labour side by side on the farm, or on the mine, or in other industrial occupation. The educated and maybe refined black, be he preacher, teacher, lawyer, or doctor, does not receive social recognition from the corresponding classes of white, and would encounter resentment were he to claim it.

The assumption or fear of assumption of equality is, in my opinion, the foundation of the antipathy between white and black, and has for its justification the following considerations. Everywhere it is admitted that the Negro race as a whole is greatly inferior mentally and socially when judged from the standard of the white man, just as individually he is held to be unattractive in many of his physical attributes. When the Negro places himself side by side with the white he invites comparison. The difference in degree of civilisation between the two races is too great

to be bridged by any suggestion of equality, and to claim it but engenders antagonism. Even when the individual Negro equals or excels in the attributes of the white the latter finds he can not accept him on his personal merits; he can not forget that the aspirant is a member of a race which is historically and at the present time markedly inferior. It may be deemed one of the tragedies of social life that the exceptional black, educated and refined, is thus held back by the drag of his race, and the intelligent white may well view it with regret; but with human nature as it is the relationship could hardly be otherwise. An individual white, from incapacity or weakness, may be far inferior in position to many a black, but at his lowest he does not forget that he belongs to a race which is much the superior, and resentment finds bitterest expression in him at any assumption of equality. Lord Bryce has shown that in the Southern United States the "poor whites" are the class which is most hostile to the Negro.

Within his own sphere then the white has nothing but regard for the black, and prejudice is wholly wanting. Their diverse attributes and standards do not enter into comparison and there is no clash. As a servant or dependent the white accepts the black as he finds him, but when considerations of equality arise he can only regard him as a member of an inferior race. Among people in Europe the Negro is accepted on his individual merits, the white there having no experience of the low state of civilisation of the race as a whole, and being therefore unable to judge the question from the point of view of South Africa. This is also the basis of the difference of treatment of the Negro in the northern and southern States of America. In the south the white cannot forget the position of inferiority in which as slaves the Negro first existed, while the northerner knows nothing of this by practical experience and, without any background of his lowly past, is disposed to take the Negro at his individual worth. In the West Indies, with all its grades of colour, problems of race are by no means acute. The whites are far in the minority, are not concerned with questions of equality, and little or no racial prejudice or restriction obtains. The Negro may aspire and succeed to legislative honours, and the same church or assembly hall receives from the highest to the lowest.

It may be noted that the personal devotion and attachment of the native servant to the family of the white man which, at any rate in the past, was such a marked feature in the southern States and to-day largely exists in the West Indies, rarely obtains in South Africa. Here the tribal organisation still persists and claims the allegiance of the native, whereas no such restraint obtains in the States and West Indies, and permanent and devoted attachment to the white more fully expresses itself.

If in the future the Bantu should rise in South Africa, and become more nearly the equal of the white in education and ability, there is no question but that the amenities in their relationship will improve, and the possibility of this affords encouragement for both races. At the present time, however, it is difficult

to contemplate social equality for white and black, even in the future; but sympathetic relationships appear likely to increase with real advancement on the part of the native. While it seems a tragedy for the educated and refined native to be subject to the barrier of social equality, his better education enables him more clearly to appreciate the psychological foundation for it. The wise and intelligent among them accept the position, for it may signify no more than do the social barriers existing in a European country. The energy, aspiration, and ambition of the exceptional native may well find their outlet in the uplifting of his people, and in the development of their racial consciousness. It may be regarded as a misfortune for South Africa nationally that the two major parts of its population are apparently to be for ever separated by social barriers, yet in practice it implies little more than do the social separations in a white community, or than the caste system does in a country like India. In these days democracy the world over has risen to claim its due share in the amenities of life, yet questions of social equality have no part in the movement, and need not have in the case of the native.

From present tendencies the native in South Africa will in the course of time be afforded all the opportunities to rise in every sphere of life and claim the position for which his abilities and tastes qualify him, and questions of equality need not enter into his considerations. The exceptional native must rise along with his race and cannot expect recognition apart from it. The display of a just and sympathetic appreciation of the situation on the part of both races will do much towards maintaining a harmonious relationship in everyday life. The leaders of thought will not be influenced by the denunciations and ravings of extremists, but will be guided by general trends; on both sides the underlying guiding principles of sociology must be recognised, and applied with justice, good-will and sympathy.

It is well that the native in South Africa should know how he compares with his fellows elsewhere. Dr. Aggrey, a Gold Coast native, who has spent over twenty years in the United States, and has recently toured a great part of Africa as a member of a Commission investigating native educational and economic conditions in Africa, addressed a gathering of natives as follows: "All white people were not bad and all black people were not good. They should let the good of both races work together. He had heard the natives in these parts complain. He only wished the Union Government would run excursions, taking thousands of natives to another colony he had just visited. If they saw how people there were treated they would say South Africa was the best country in the world. White people would help them if they worked and showed that they were worthy of help."

The Bantu Assimilative but not Originative.

The past history of the Negro in Africa would appear to prove that, of himself, he is incapable of rising from his lowly state; for all through the ages he has evolved none of the attri-

butes of a civilisation, while in the same period other peoples have progressed in one direction or another. He has directed none of the forces of Nature to his advantage, nor has he discovered any of Nature's secrets and moulded them to his needs. As Mr. Putnam Weale, in "The Conflict of Colour," says: "The black man has given nothing to the world. He has never made a nation. He belongs to nothing but a subject race. He has no architecture of his own, no art, no history, no real religion, unless animism be a religion. His hands have reared no enduring monuments save where they have been forcibly directed by the energies of other races." In this respect the Negro is far below and altogether apart from the coloured peoples of India, China and Japan, who have evolved high civilisations of their own. We have much to learn from them, but the Negro contributes little or nothing to the world's stock of knowledge; of all the great races, his has given the least evidence of originative and constructive powers.

Yet though the power of originality may not be in the Negro, there is much to indicate that under favourable conditions he possesses to a high degree the capacity for assimilating the attainments of others. And for this his state of mental negation is in his favour. He starts his racial history afresh on coming into contact with the white and, bringing nothing with him, he has nothing to give up; there is nothing to be displaced; his mind is open and receptive; he accepts implicitly once he understands. The representatives of the race who have risen to professional rank may be taken as evidence of the possibilities of absorption, but we have yet to discover that they are capable of conducting original investigation or are in any ways inventive. From these examples there is no reason to suppose that, given the opportunity, the black cannot assimilate the full measure of the white man's acquirements, that is, all that the white man has gained during his centuries of progressive effort.

Religious beliefs and practices are perhaps the most deep-seated of all the attributes of a people, yet those of the Negro are held but loosely. The Rev. Henri A. Junod in his Presidential Address before the Anthropological Section last year remarked: "The Christian God very easily supplants the ancestral god in his prayers. . . . The Christian religion is bound to conquer the Bantu in a comparatively short time." This was written after thirty years of experience of the native. The whole attitude of the Negro in South Africa towards the white man is one of dependence and receptiveness. He practically gives up all he has and takes up the white man's religion, education, customs and mode of life. He has but little independence and initiative in measures which make for progress. This reliance and absence of any constructiveness is strikingly revealed in books written by the native dealing with his own problems, such as "Native Life in South Africa," by Sol. T. Plaatje, and "The Bantu," by S. M. Molema (1920), and others by Jabavu. Contrast the African Negro with the people of Japan. The latter had evolved a high civilisation of their own. Yet on coming into contact with the

white they quickly realised that to hold a position among the advanced nations of the world they must develop on other lines. Rapidly they discarded the old order and became "westernised" by their own efforts, and still send their brightest intellects to universities in Europe and America to cull the best. The Negro on coming into contact with advanced nations awaits them to raise him to their own standard.

As illustrative of the dependent attitude of the black upon the white Dr. Aggrey, with his enlightened appreciation of both the virtues and failings of his fellow natives, is reported as follows: "In the course of his remarks he vigorously preached the gospel of work with his hands, especially farming. He strongly deprecated natives looking to Europeans for help. The white man had given them lots of things, and the time had come when the blacks should have self-respect enough to do something for themselves."

The Negro is not to be regarded as an example of "arrested development," as is so often asserted in explanations of his backwardness. The zoologist would rather maintain that his racial characteristics are germinally different from those of the white. Many of his physical characteristics—colour, hair, facial features—are hereditarily different, and we may expect his mental attributes to differ likewise, though these are not determinable in precise terms from the data at present available. If we hold that man had a monophyletic origin, as seems likely, then mutative changes have since occurred which have given the marked hereditary characters now differentiating the white and the black. How far under his changed environment, in contact with the white as preceptor and example, the black will show himself inventive and originative only the future will reveal; but his history hitherto suggests real constitutional limitations. We need not apologise for his shortcomings by remarking that he has been in contact with the white for only a few generations; had originality been innate it would ere this have displayed itself independently. It should also be clearly appreciated that his hereditary mental nature will not change any more than will his physical nature, however many generations he may be associated with the white. We have ample proof that it is highly responsive and readily assimilative, but we do not know how far these qualities will carry him.

It is manifest that if we are to live with people, we should know something of their nature and what they are likely to do and become under given circumstances. The black man in close sympathetic association with the white is a new problem, as he is a new creature. We cannot predict to what he will ultimately attain. We can wait until time slowly reveals it to us, but we can also forestall by investigation and experiment. This latter aspect makes a strong appeal to the man of science. Dr. Loram has already carried out certain experiments in schools to determine the mental powers of Bantu children in comparison with Indian and European, and described them in his book, "The Education of the South African Native." More investigational

work along these lines is needed and in the direction of experimental psychology. It is greatly to be desired that the members of the Native Affairs Commission will fully realise the opportunities of research before them. Without data as to what are the real potentialities of the Bantu how can they advise as to the policy to be pursued?

Racial Solidarity.

To anyone who reflects upon the sociological problems of South Africa the question will continually recur, how are the various constituents of the population likely to arrange themselves in the future? Though perhaps at first sight the matter is not very relevant to ourselves, it yet makes a strong appeal when we contemplate what may be the conditions for our descendents. We can only predict the future with any assurance from a study of the present and from the tendencies it reveals. Three courses at least are possible: (*a*) Each racial group may separate itself from the others, retain all its distinctive characteristics, and lead its life apart and independently. (*b*) All the groups may intermingle and blend, lose their individuality, and form a more or less homogeneous people, an approximate uniformity of all the diverse elements as regards colour and other physical attributes, as well as of the higher mental and spiritual faculties. (*c*) The present arrangement may continue and each group retain its primary racial distinctness, and yet intermingle for the everyday affairs of life.

The adoption of the first possibility, that of complete isolation or segregation of each race, makes a strong appeal to the superficial view, but is not feasible in practice. There are obligations which can not be put aside. With modern humanitarian ideas of the obligations of peoples to one another the white could not leave the native isolated in his lowly condition, with all his barbarous customs and practices; nor is a continuance of intertribal warfare possible in contact with a civilised people. The latter have now to help the native towards something in lieu of these discarded practices, to provide him with interests, and to assist him to a life in conformity with a fixed and settled social organisation. Having come into contact with the white man and realised the amenities which civilisation confers, the native himself does not desire a detached existence and resents enforced segregation. His leaders especially call for education, and help and guidance towards a life more like that of the white. The European must respond to his obligations and in matters of education, of agriculture, and of existence generally, the condition of the native both within and outside the Reserves is rapidly improving

The case of the Maori may be instanced as an example of successful segregation of coloured and white apart. But the New Zealand native is of an altogether different nature from the native of South Africa. He is self-contained and can lead his own life successfully within a limited area, without interference from the white, and yet in harmony with humane ideals. The Negro apart has not the innate power to maintain such a life. The results in

Liberia and Haiti may be recalled. Whenever in intimate relationship with the black, the white man must exercise a benevolent guidance, in conformity with the claims of universal humanitarianism.

Many arguments could be adduced showing the impossibility of the Indian, the Malay and the Eur-African being isolated, and leading their lives apart from the European; though segregation is sometimes suggested for the Indian in Natal. In pressing segregation it must not be overlooked that from the earliest days the native and the coloured have been deemed a necessary factor in the industrial machinery of the country.

The second possibility, namely, that all the races in South Africa should blend together and form a more or less uniform people has been suggested, and some writers maintain that this will be the final state of the various races and nations at present making up the world. The idea of a physical, mental, and spiritual homogeneity of all peoples is but a delusion, and its contemplation is an absolute abhorrence to any Nordic white living in a settled community of blacks, where racial attitudes have had time to crystallise. One may see a suggestion of it in new countries on first opening-up, and also in seaport towns where racial regard is loosely held. It raises the whole question of the permanency of racial barriers, so ably discussed by Dr. Keith in his paper "Nationality and Race." To the present writer the modern tendency in all settled communities of different racial elements is wholly against the breaking down of the barriers of race. With education and enlightenment, racial and national determinism, in the restricted sense of the term, is unquestionably spreading. Mr. Stephen Graham in his book, "Children of the Slaves," sees no evidence of fusion between the black and white of the Southern States of America. Race-blending has, indeed, the approval of writers like Sir Sidney Olivier, but on the truly unsatisfactory ground that it improves the inferior race.

The third possibility, that each group will retain its racial distinctness and yet intermingle in the ordinary affairs of life is that for which South Africa offers the greatest support. Not only is it the general arrangement at the present time, but the whole tendency appears to be in the direction of its accentuation; group or racial solidarity is on the increase, as the various peoples settle down and begin to realise themselves as a fixed community.

In many respects racial consciousness is in process of making and also of re-making in South Africa, and many intermediate stages are offered to the sociological enquirer. Moreover, the really big question is presented as to how this racial solidarity will relate itself to South African nationalism, for upon this hangs the future of South Africa as a nation. Is the solidarity of the various races to be of such a nature that it will be subversive of South African nationalism? The whole question requires most thorough examination. We can but touch the fringe of it later.

As regards the Bantu it is manifest that as a result of his close relationship with the European his racial conscience has

undergone and is still undergoing the most profound change. His whole conception of racialism has to be re-made and re-shaped. Involved in the changes are his relationships to the rest of the Bantu race, his tribal allegiance, and his attitude to South Africa as a nation; moreover, all these differ according as we are considering the native inside or outside the Reserves. As shown above, the Bantu gives up his all and assimilates practically everything from the white. This unquestionably results in a weakening of the tribal and racial bonds; but it would appear to be only a phase, and with education and general advancement the awakening of a new racial sense will take its place. The Indian and the Malay have brought with them their own manners and customs, and their own way of looking at things. They live beside the white man and serve his requirements without assimilating the white man's life, thus affording a great contrast to the Bantu. They are apart in their social and religious life and in their general organisations, and are acquiring a solidarity and a South African life of their own.

Even the Eur-Africans, who by virtue of their origin have no independent racial consciousness, are rapidly developing a solidarity. They belong neither to white nor black, Indian nor Malay, and socially they lead their lives apart and have their own schools, churches, and other organisations. More than any of the others they present the student with the problem of the group mind in the making.

We see then that the Bantu, the Indian, the Malay, the Eur-African and the European, all constituent parts of the South African nation, intermingle in their every-day avocations and act as one people. Yet when their daily task is over they disentangle and separate, and each group leads its emotional life apart and according to its own fashion. For industrial purposes they may be regarded as one complex, each within its own sphere; but in their free voluntary life they segregate themselves apart, and each follows its own nature. Moreover, as the realisation of racial consciousness grows, the bonds of organisation will get stronger and stronger.

Wisely directed racial determinism among the various heterogeneous elements in South Africa would appear to be worthy of encouragement. For from what has gone before it is manifest that the racial barriers are too great to admit of intermingling in the ultimate personal relationships of life, or of absorption into a common whole. Hence if each develops along its own course all racial contrasts, implying higher or lower, or superior or inferior, are avoided, there will be no racial clash socially, for each will lead its own life apart and comparisons will not obtrude. It is especially valuable in that its development offers a legitimate objective for the aspirations of the more advanced, intelligent members of each group. No individual can have a worthier purpose than the advancement of his own race, and all will admit there is ample scope for it among the peoples we are considering.

The presence of so many distinct elements in a community, each with distinct aims and aspirations, might seem to have a weakening effect, but with racial barriers as they exist no other course appears possible. It is recognised from the beginning that these are South Africa's problems, and we cannot escape them. We have to face the fact of racial distinctions, and direct them as seems most wise. Repression of any element is inadmissible; the principle of fairness and sympathetic treatment is accepted.

Experience hitherto has shown that, while perhaps weakening, the admixture of peoples is not necessarily antagonistic; moreover, it applies only to the personal social side of life, not to that of collective effort. Thus it obtrudes in education, religion, sports, games, and the individualistic side of life generally, but not to the industrial and economic issues. In towns separate schools exist for white and coloured, and the same clergyman may administer to a church of white adherents, to another of coloured and to another of native. A distinguished visitor, such as the Governor-General, would meet independently an assembly of white, coloured, and native, and receive fervent expressions of loyalty from each. On industrial and business issues racialism, in theory and also largely in practice, is non-existent. The individual in general occupies the sphere for which his qualifications befit him. As those of the native and coloured are generally lower than those of the white, differences are manifest, and would appear to show racial discrimination, whereas they are dictated mainly by considerations of ability.

National Loyalty and Racial Solidarity.

In the foregoing we have regarded the Bantu and other coloured peoples only from the South African point of view, not as a part of the larger world problem of the coloured races as a whole in their relationship with the white. The dire results which may one day arise from the conflicting interests of the white and coloured have been fully expounded in works such as those of Mr. Putnam Weale, "Conflict of Colour," and of Dr. Lothrop Stoddard, "The Rising Tide of Colour." While no one can predict with certainty how the present racial antagonisms will shape themselves in the future. the conclusions these writers present are sufficiently serious to merit special study in South Africa. Stoddard is particularly insistent upon the fact that the chief conflicts which count in history, the late war excepted, have been inter-racial. He naturally assumes that differences of race will determine the main conflicts in the future, and that the white race, on account of its numerical weakness, may not always prove to be the victor.

There is much in support of this view, but it is also relevant to suggest that, with the more enlightened and more sympathetic attitude now coming over the relationships of white and coloured, future conflicts will not necessarily be on racial lines, but combinations of races against combinations. The diversity of races and colour represented by the combatants in the late war may not be without significance in this connection. As already indicated,

the general trend of opinion and effort in South Africa is unquestionably in the direction of making white and colour sympathetic co-partners in the national life, each in its own sphere; and it is well worthy of consideration whether in the end national bonds and loyalty will not replace and be stronger than racial. To admit the possibility of this is much to ask of believers in the paramount solidarity of races. If, as its supporters sincerely hope, the treatment meted out to the native in South Africa should demonstrate the reality of national loyalty as against racial the country will have conferred a signal service on humanity, in dispelling the nightmare of future inter-racial conflict. Probably no other country is so well situated for a racio-national experiment of this far-reaching import.

At the present time national loyalty is undoubtedly a conspicuous feature among the various coloured peoples in South Africa, as was loyalty and support to the Empire during the late war. Loyalty to the Government and to the Crown is manifested on all public occasions, and there is no reason to question its reality. Whether it can be relied upon in times of inter-racial stress, whether adherence to country will transcend obligations to race, only the future will show. But it is the aim of its statesmen, its leaders of thought and action, to bind by fairness, justice, and sympathy all the races into one true South African nation.

White Solidarity.

Not only does South Africa contain a diversity of races which do not blend, but it also offers one of the most notable examples of the continued separation of stock derived from two closely allied European nationalities, Dutch and English. A somewhat analogous lack of fusion also occurs in Canada between French and English, but here geographical isolation is undoubtedly a factor, whereas in South Africa the two peoples freely intermingle, both in town and country.

The lack of solidarity of the two white nationalities in South Africa can only be understood when viewed historically. The Dutch are mainly the descendants of the settlers who came in the seventeenth century. In the two or three hundred years of their occupancy they have largely severed their connection with the mother country and have evolved a real South African nationalism of their own, and become deeply attached to the country and all that it holds for them. They have wholly thrown in their lot with the country of their adoption and their lives are centred therein. Few now come from the country of origin, Holland, and these have little or no influence in keeping awake any sentimental regard towards it. Of late, however, many efforts have been made to draw the intellectual and economic ties more closely. The British on the other hand, in any numbers, are recent immigrants, coming mostly within the last century, while others still continue to arrive. The older settlers and their descendants have scarcely yet had time to lose their sentimental connection with the mother country, and it is kept alive by the constant influx of newcomers,

by intercourse in trade and commerce, and by all that is involved in the fact that it is a British Dominion.

We thus have the one people living their lives centred in South Africa and wholly devoted to its interests, while the other have not altogether detached themselves from their original nationality, and are disposed to regard South Africa through the eyes of England. The one desires to build up a real South African nationality apart, the other has barely yet reached the stage where South Africa is accorded the one and only consideration in national regard. The one tends to view South African nationalism without special reference to any other nationality, the other also desires to build up a South African nationalism, but in close association with the British Commonwealth of Nations.

Viewed in this manner the two aspects can well be understood and each calls for sympathetic recognition. They are the hard facts of sentimental nationalism which will manifest themselves in face of all material considerations, and have to be reckoned with in the up-building of the country. Appreciating and sympathising with their reality no Britisher would desire the "Afrikaner" to give up the national consciousness which he has evolved in South Africa, nor would the latter, in his turn, ask the Britisher to sever himself from all that his country and empire mean to him. In neither case, however, is the retention of these sentiments incompatible with the building-up of a real South African consciousness, and the recognition of this is involved in what we may term "the new nationalism of South Africa." Mutual regard and good-will obtain among the best types of both, and respect for one another's ideals. "National instinctive tendencies are curbed and guided by the higher reasoning centres of the brain."

The attitude that is gradually being evolved assumes that each stock will retain its primary nationalism, with its sentiments and traditions; while in all that concerns the real welfare of South Africa the two will work together with the determinism of one nation. How far the latter will in the end replace the former time alone will reveal. In the interests of true South African solidarity it is devoutly to be desired that a study of the sociological principles involved will do something to lessen the gap which separates the two peoples, so that all may concentrate wholeheartedly upon what makes for national good.

The possibilities of ultimate fusion of the two nationalities seem bright with promise. For, as McDougall in "The Group Mind" says: "The crossing of two closely allied racial stocks seems to have a tendency to produce a cross-bred race superior to both parent stocks, and especially to produce a variable stock. It is, I think, probable that frequently repeated blending of allied stocks in Europe has been the fundamental biological condition of the capacity of the European peoples for progressive national life."

Genesis and Reclamation of the Indigent White.

The 'poor white" constitutes a social problem of much complexity and grave concern. The class is scarcely known to you in Natal, since the conditions which produced it elsewhere have

never existed in the Garden Colony. It is a problem highly specific in its nature, and its solution appeals to the geneticist rather than to the anthropologist. Had the question been one concerned with the improvement of domestic stock it would have been submitted to him forthwith; but as a problem in human welfare, it has been relegated to the politician and the philanthropist.

In his experimental breeding work with animals the geneticist is impressed with the permanency of the fundamental characteristics of a race, and at the same time with their plasticity in the individual as a result of environmental influences. He is well versed in Galton's phrase: "Nature and Nurture," and is accustomed to contrast hereditary and acquired characteristics. As a working basis he proceeds on the assumption that acquired modifications are non-transmissible, and that each generation starts where its predecessors began, not where they left off. The germ plasm remains continuous and unalterable, and individual attainments are for the generation only.

In approaching the poor white question the geneticist first enquires as to the nature of the original material from which the class has come. From this he can ascertain to what degree the degenerate condition of to-day is evidence of an originally retrogressive nature, or to what extent it has been impressed by force of circumstances. If primarily degenerate his science can offer no encouragement; the individual is by nature incapable of fitting into the complexities of modern life, and can only exist on support from others or under some simpler state of society not yet evolved. If, however, the degeneracy be the result of circumstances there is hope for recovery; the blood is good, but the chances have been against it.

Historically, there is no uncertainty in estimating the sociological value of the original stock from which the class of indigent white has come. It is a derivative from two of the most virile nations of Europe, the industrious, adventurous, sea-faring Dutch and British. As already seen, the Dutch followed in the wake of Van Riebeek, mostly from 1652 to 1806. They were largely soldiers, sailors, artisans, farmers and servants with a leavening of the administrative, commercial, and professional classes. In any numbers the British arrived from 1795, when they first took over Cape Town, and were much of the same types, the purely settler class predominating in the last century, notably the four thousand 1820 settlers in the Eastern Province. On the whole the immigrants may be held to have been no better and no worse eugenically than the corresponding classes of their time in Holland and Britain, the descendants of whom make up the two nations to-day, while the sturdy qualities of independence and adventure were probably above the average. Writing in despatches of the men who took part in the Great Trek of 1836-37, the Governor, Sir Benjamin D'Urban, describes them as "brave, patient, industrious, orderly, and religious people; the cultivators, defenders, and tax contributors of the country."

If we accept that the ancestors of the poor white class were neither better nor worse than the corresponding classes in Europe we have to account for their present state of degeneracy, in which they have become for the most part incapable of providing for themselves more than a bare subsistence. Opinions may vary as to some of the causes, and the relative value of the different influences, but a close study of all the circumstances is highly convincing that they are inherent in the natural conditions in South Africa to which the trekkers subjected themselves. The general trend was towards isolation, to removal from centres of activity and progress to distant parts where each could lead an untrammelled existence, free from every form of religious, political, and economic restraint, where land could be had for a mere nothing. The free, simple, hunting, pastoral life, and the lure of the land, made a strong appeal; the country was thinly peopled and ample room was available for increase of family and stock, or for further migration if necessary. The presence of the native was a disturbing factor, and at the same time inhibited any healthy stimulus to manual work, while the hard natural conditions prevailing in undeveloped South Africa, with the accompaniment of drought and flood, discouraged agriculture and all forms of enterprise. The conditions to which the early settlers were subject are well expressed by the South African poet, Mr. F. C. Sclater:

"Many evils come to try
Their fortitude: their cattle die,
Sometimes, all their streams run dry
When, 'neath the sun's unflinching sting,
Earth is as a tortured thing,
That quivers in its parchèd pain
And begs, with blistered lips, for rain!
Sometimes, when their fields are green,
Russet clouds on high are seen—
Hissing clouds that fall like rain
Over valley, field and plain—
Hissing clouds that pass in haste
And leave behind a desert waste."

With the gradual filling-up of the country and the absence of new areas to which to migrate, the farmer had to restrain his wanderings, his family growing larger, the farm sub-divided, and the resources of the land less. Except in the most favoured spots he gradually found himself becoming poorer and less capable of providing a decent existence. Absence of education and of stimulating contact with his fellow-man and with the outer world engendered narrowness of outlook, and lack of sympathy and plasticity for progressive measures. It was manifest that the trekker had struck out on wrong lines and could not retrace his steps; he stagnated, and his virile nature succumbed.

The results were such as would be expected, and have little relationship to national characteristics; they would in all likelihood have been the same with the people of any nation, subjected to the same environment. The descendants of the Dutch comprise

by far the majority, since they were the first settlers, and have the longest been subject to the deteriorating influences of the remote country, the back veld. It is their adventurous and freedom-loving nature which has been their undoing. "Our poor rustics to-day are the depositaries of the traditions of the Great Trek, and the children of the pioneers of civilisation in this wide land." But South Africa owes much to them for their pioneering efforts in the opening-up of the country.

As regards the proportion of the population now involved, rural and urban, we cannot do better than quote the estimate of Prof. W. M. Macmillan in his lectures on the "Agrarian Problem," who writes: "We might state the case thus, that nearly one-twentieth of the white population of the Union are in permanent absolute poverty, many of them perhaps demoralised beyond redemption; in addition, we have to reconstruct society so as to prevent perhaps considerably more than another twentieth from being dragged by adverse, but remediable conditions, down to the level of those submerged." The second Interim Report of the Unemployed Commission, just published, estimates there are 100,000 to 120,000 poor whites in the country, representing some 25,000 families. How seriously the matter is viewed by the legislature is reflected in the following Resolution passed by the Senate on the 8th April of the present year: "The House viewed with alarm the dimensions of the poor white question, and requests Government to continue to make every effort by means of irrigation schemes and other works to induce these people to leave their urban environment and go on the land."

The production of a large indigent class of land-owning farmers, descended from virile stock, is probably unique in social evolution, and has an intense interest for the eugenist. It is to be ascribed to the depressing effect of isolation consequent upon the sparsely populated character of South Africa, the harsh pastoral and agricultural condition of the country occupied, and the presence of the inferior Bantu race. In other countries the indigent population is constituted largely of the inefficients and incapables by nature; but the originals of South Africa's submerged were efficients. The class is specific in its origin; it is for the most part a result of historical and geographical factors acting on an otherwise desirable strain.

In the meantime, and more especially during the past twenty years, a new agricultural and industrial era has dawned upon South Africa. The extension of railways, the manifold activities of a vigorous and well-directed Department of Agriculture, the development of schemes of water storage and irrigation, successes against animal diseases, the introduction of high-grade stock of all kinds, the advent of the ostrich and lucerne and fencing, the encouragement of fruit and grain production, and better methods of disposal and export of products have placed pastoral and agricultural effort on an assured basis, and one at the same time both progressive and intensive. Mining, metallurgical, and manufacturing industries have made their advances and wielded an influence in the country's advancement.

But the stimulating influences from these have failed to reach the isolated trekker on his distant farm or, reaching him, have found him cold and unresponsive. The incubus of years of depressing isolation, submissive to nature, cannot lightly be thrown aside. Meanwhile the land has made its appeal to a newer and intensely vigorous type, with capital and intelligence meet for development, infused with the new ideals in agriculture and awake to its possibilities. The townsman of all classes, merchant, official and professional, has responded to the call of the country and its life of freedom, while the farmer already prosperous has extended more and more. The glamour of the land prevails in South Africa. The inevitable has happened. The trek farmer has relinquished his feeble hold on the land, and has either become a dependent upon the newcomer or drifted helplessly into the towns, scarcely more capable of a livelihood there than in the country. Within recent years one has witnessed whole districts in which the pioneer farmer, pathetic in his helplessness, has been replaced by the modern progressives; the country advances in material prosperity, but the individual succumbs. The original trek farmer was before his time, and cannot retrace his steps; he failed to foresee the results of isolation in a new undeveloped country, great with possibilities but special in their nature, only to be won by strenuous, intelligent effort directed by science. The new occupant takes on where the old leaves off, and has knowledge of the requirements for success.

Recovery of the poor white as a class is not without its hopefulness. But for adults, however, the geneticist has nothing to offer. They are the inheritors of the two or three hundred years of environmental influences, unfitting for modern South Africa. The effects have been cumulative from generation to generation. and have moulded the individual from the day of his birth. Even when transferred to ameliorating surroundings his efforts to shake off the incubus of habit are for the most part futile. In general, he is incapable of making a decent livelihood either under or away from his old surroundings, incapable of adaptation to the more strenuous and complex conditions now normal to South Africa. He but accentuates the ordinary poverty and distress of town life. His day of opportunity has gone by; he remains a genuine subject for philanthropic effort, designed to help to ameliorate the condition of the incapable and the unfortunate in life's struggle. His position calls for the exercise of all of the virtues of altruism, and truly noble responses have been forthcoming.

On the other hand, the possibilities of recovery of the new generation inspire one with the highest hope. The immigrant stock has been shown to be virile and efficient, and the quality of the blood has not changed. The deteriorating influences affect only the individual; the new life starts with all the original potentialities of its class, and can be moulded to the possibilities of its ancestral forbears. But from the beginning it must be freed from the environment which has enfolded its immediate forbears, ere

it is moulded in the same depressing manner. It must be placed under influences such as will fashion it in harmony with the social needs of to-day. There is no escape from these genetic requirements. Allow the new generation to grow up under the old parental surroundings and it repeats the parental incapacity; subject it to favourable conditions and it responds, fitted for the complex needs of its class.

The principle of the early segregation of the new generation under improved conditions is not here advocated for the first time, but its enforcement from the realm of genetics accords it the support of scientific authority. The application of the principle, however, presents great difficulties which cannot now be entered upon. Some attempt has already been made by means of industrial schools and institutions; a national asset is at stake, and the State cannot shirk its responsibilities. Manifestly much propaganda will be necessary ere intelligent sentiment in support of the need is awakened on a national scale. Yet a nation's problems receive their enforcement at particular periods in a country's history; and in these days of awakened national aspirations, re-arrangements of social ideals, and political stability, the time may be deemed opportune.

An effort to arouse public sentiment on behalf of the submerged part of the nation should appeal with peculiar force to the University youth of South Africa, appreciative of the blessings he has himself received from the State in fitting him for a position of enlarged social worth. Infused with the spirit of true South African nationalism he should in turn be prepared to strive for a chance in life for his humble brother. It is fundamentally a problem of education, but with unusual features. It is suggested that University Associations be formed to investigate the problem in all its bearings, and to constitute nuclei from which may radiate influences destined to arouse a sympathetic and intelligent public opinion. No nobler nor more inspiring call could come to the educated youth of South Africa, infused with true nationalism as a part of a true humanitarianism, than to devote himself to the reclamation of those in economic bondage, impressed by a formative period in his country's history. In reflecting on the good work of Mr. Geo. H. Hofmeyr, Secretary for Higher Education, in the encouragement and co-ordination of the efforts in Child Welfare and Industrial Education, it is permissible to express the hope that the Universities themselves may follow his lead in the recovery of submerged South Africa. No other part of the community is able to bring to bear upon the problem such independent and enlarged sympathetic minds trained in the conditions necessary for the right development of others. Studies such as those emanating from the investigations of Prof. W. M. Macmillan may well be taken as inspiring models.

In the assurance of tangible results a movement of this nature is wholly apart from philanthropy as generally exercised, and makes a different appeal. The one is wholly remedial, whereas the other is plainly palliative. Philanthropic effort usually concerns itself with the naturally deficient and the incapable, and

aims at making his lot more bearable; but it is without permanent eugenic value, indeed, unless wisely administered, it may encourage degeneracy, by affording the means of bringing into being others of like character, able to continue the bad stock. Social sentiment has not yet reached the stage where it will permit of measures for the physical elimination of the undesirable. The reclamation here advocated is concerned with the birthright of those having a real potential value to South Africa.

There is some reason to hope that the indigent white will insensibly disappear as a special class. If the account of the conditions under which he has been produced be correct, namely, the hard pioneering stage in the development of South Africa, then with the improved conditions now prevalent he ought gradually to be absorbed. The circumstances which produced him no longer exist and, especially if given a new start, all but those inefficient by Nature should recover. The new agricultural and industrial development of South Africa carries with it the call for this regenerated class. Everywhere is the growing demand for efficient whites. Immigration is good and is immediate in its returns, but the recovery of one's own carries a higher obligation. Farmers demand efficient whites for their intensive agriculture and high pastoral attainments, industrialism calls for a high level of production only possible from efficients.

A New South African Nationalism.

Since Union a new nationalism has been slowly dawning over South Africa, and finds its best exponents in the leaders of the political parties, and also in contributions to recent South African literature. But the movement is largely apart from politics, and indeed, is opposed to them whenever they appear detrimental to the true interests of the country. The aspiration has found an expression in the fusion of two of the political parties, their hitherto slightly divergent interests now being subordinated to what they conceive to be the common good. The movement is a unifying one, but is not exclusive of the old nationalism. Relegating the old to the background, it is one to which the peoples of both nations can conform.

One of the most potent influences making for this new development is the experience of the younger generation overseas during the war. Just as the dweller in any country never fully realises what it is to be a member of his nation until he travels, or comes into personal contact with the members of other nations, so the South African, whether of British or Dutch descent, never fully experienced his own nationality until he went abroad. In contact with others he realised for the first time that he was South African; his full national consciousness was born in him and he was inspired by it. Returning he is infused with this new sense and with a devotion to South Africa as South Africa, and a determination to devote his best powers to her welfare. England as the centre of the British Commonwealth of Nations he views through the eyes of South Africa, not as the new arrival who regards South Africa through the eyes of the country he has left.

The selected youths of the country who have been sent abroad for study also return with this enlarged devotion to South Africa as a nation, and can view the latter in its proper perspective.

The growth of a new national consciousness on the part of Europeans and their descendants in a new country has many features of interest. The newcomer, as remarked above, first views the country through the eyes of the one he has left. Usually this attitude persists only for a time, particularly in the case of the permanent settler. Gradually he begins to regard the affairs of his adopted country as bearing closely on his personal interests, and those of the mother country become less and less obtrusive. The first generation, however, rarely loses a primary regard for the old country, and is prepared whole-heartedly to uphold at all costs it and all for which it stands. The second and succeeding generations, however, have none of this intimate attachment. They only know the country of adoption and all their interests, social and material, are bound up with it. They wisely throw in their lot completely with the new country, and the old recedes further and further; a new individual national consciousness is evolved. The process is well exemplified in South Africa in descendants of both Dutch and English stock. They have developed a new national life along its own lines, with its own traditions and aspirations; moreover, they are disposed to view with disfavour the newcomer from the country of origin, inclined maybe to disparage the new nationalism in favour of the old. Each South African, British or Dutch, is naturally proud and jealous of the good name and repute of his adopted country in which he has a share, and to the progress of which he has given his all.

This is the unifying process we see on its largest scale in the conglomeration of nationalities in the United States. It has also consolidated with a new national solidarity the various British stocks in New Zealand, Australia, and Canada, and is rapidly effecting the same for both British and Dutch in South Africa. A sentimental regard still persists for the history and traditions of the old country, but it is secondary to that for their own. Dr. Keith has truly remarked: "The arrival in a new land of immigrants from diverse countries breaks down the national barriers within which they were born and bred. A national spirit breeds true only in its native soil; when transplanted to a new land it becomes plastic and mouldable. A new country dissolves ancient nationalities"; and, he might have added, "invigorates a new nationality."

A Benevolent Aristocracy of Ability.

If the conclusions which I have presented are correct the Bantu, Indian, Malay, Eur-African, and European will remain distinct elements of the population of South Africa, commingling in every-day matters, but in their social lives apart, each according to its own group consciousness, all loyal to their country and empire. It is in the competition in everyday affairs, in the overlapping for trade and industrial purposes, that any serious clash

is likely to occur. How the different elements making up the nation will arrange themselves in industrial and economic competition is our cardinal sociological problem. It must be conceded that on the whole the present relationships are workable, and we may well consider how far they are likely to continue.

In trade, industry, and the general affairs of the country, all having equal opportunity, the leaders will be those manifesting the greatest ability; they will be the directive forces of the nation, and the others less endowed must naturally occupy the lower strata in accordance with their lesser powers. In a white community, such as exists in most European countries, we may allow that natural endowments are fairly uniformly distributed among the different classes of the people and, given equal opportunity, outstanding individuals will arise from any level. But it is otherwise in a country with diversity of races. Physical, social, mental, and spiritual characteristics are hereditarily different in the various human races, and uniformity of opportunity will in no measure eliminate them. It is readily conceded that the physical divergencies are constant and unalterable, but the hereditary constancy of the others is not so manifest; yet it is none the less true, despite the dictum that "all men are born equal." In the whole human family scarcely any greater physical contrasts occur than those between the Bantu and the European, and their mental attributes are just as diverse. No sane person would contend that given equal opportunity, or placed under the same environment, these hereditary differences would be nullified; they are represented by germinal factors and the germ plasm does not ordinarily change. To determine their relative status in the future we may attempt to appraise the hereditary qualifications of the various South African peoples, though it can be done only in the most general fashion; for it is here that the greatest need exists for experimental data.

The many negative qualities of the Bantu have already been noted. Looking to his past history and present attainments there is no reason to hold that in all-round executive ability he will never more nearly approach the white man than he does at present, though we may allow for the exception and for the fact that as a race he has yet to prove his full cumulative capacity under a new and sympathetic environment. The Indian in South Africa is admittedly a selection from a labouring class of low caste. In India is to be found some of the most desirable blood in the world, but not much of it flows in the veins of the coolie. Heredity is all powerful, the blood of the labourer produces the labourer, and outstanding individuals do not arise from ancestrally poor stock. The mixed group we call the Malays have shown little capacity beyond that necessary for industrialism, and are happy therein; natural endowment for the higher attainments of life is questionable. The Eur-Africans by their very origin are mosaics of the Bantu and European, and, in the main, are from the lower types of the latter. They cannot wholly possess the innate qualities of the pure white.

Thus the hereditary attributes of all the peoples of colour in South Africa are markedly inferior to those of the white in all that pertains to the requirements of modern civilisation, and there is every reason to expect that they will remain so in the future. For in considerations of this nature the teachings of zoology are overwhelmingly in favour of the unchangeableness of the germ plasm. We may add the opinion of Dr. Stoddard as to the outstanding merit of the white race from which the Europeans in South Africa are derived: "The white race divides itself nto three sub-species—the Nordics, the Alpines, and the Mediterraneans. All these are good stocks, ranking in genetic worth well above the various coloured races. However, there seems to be no question that the Nordic is far and away the most valuable type, standing at the head of the whole human genus." English and Dutch are predominantly Nordic, and it is in the daily competition with these that the Bantu, Indian, and Malay are to lead their lives. In the commingling of these races in South Africa there can be no question as to which will be dominant. In his hereditary endowments the white is far more gifted than the coloured, and must lead. Dominance, however, is not arrogance, nor does superiority necessarily carry with it harshness or unfairness.

The white man is imbued with sympathetic good-will towards the coloured, and is prepared to do all that is reasonable to help him to rise to the highest possibilities of his natural powers; but in the complexities of industrial life each must necessarily occupy the sphere for which his attainments best fit him. There is encouragement for all in a natural distribution of this kind; and it will not be overlooked, both by white and black, that hereditary powers are of little avail unless developed by education and training.

If the white man has to lead in South Africa he can do so only by training his superior inherent powers, and in my opening remarks I indicated the wide facilities now available in this direction. The native also is securing higher educational opportunities, even to university standards, as at Fort Hare. It is only the superior mental endowment of the European which will keep him ahead, but without training this will count little in the days to come. The racial struggle in South Africa will in the end be one of ability; repressive measures, even if attempted, can be only temporary, and will be the breeders of discontent. By virtue of his higher intelligence, not because of absence of colour, I see the white man leading in South Africa; he will constitute an aristocracy of ability, benevolent to the races less endowed. But the sore of the indigent white must first be healed.

I cannot close without some reflections on the type of white man which South Africa tends to produce. Whatever he was on first coming here he and his descendants are subject to a different environment from that in Europe and are moulded thereby. I claim to have experience of the more highly educated youth, the public school and the university type, also of the farmer of the

progressive type, those who are and who will become the leaders in our national destiny. During the late war the South African youth found himself judged beside the youth of England and of the Dominions, and assurance was everywhere forthcoming that he stood for gentlemanly action, uprightness, intelligence, and ability in leadership, as well as valour in war. A type imbued with such virtues I hold to be that which South Africa's environment produces, and will produce more freely under the settled conditions ahead. The presence of an inferior dependent race in sympathetic relationship, acting on the right type of manhood, engenders the virtues of good-will, self-control, self-respect, initiative, independence, and leadership. Our sunny clime may not conduce to overmuch study of books. The call is to the open and to the veld, which bring expansiveness of mind and effort. Sustained mental and physical vigour may not attain the standard of that of older climes, but there are compensations in reflectiveness and freedom. A new country, it provides opportunity for all, black and white. A nation which has given the world a Smuts and a Botha, and produced a Hofmeyr, a Steyn, a De Villiers, a Merriman, and an Olive Schreiner, may well aspire to play a noble part in the future, and rouse a national pride in her sons.

I conclude with words recently written by General Smuts in another connection, and express the hope that they may be said of South Africa in the future: "It has ever formed a platform for the championship of great and disinterested causes. It has ever held aloft a great banner to which lovers of the great human causes could repair. Its appeal has been to what is best in human nature, to the good sense and human sympathies which go deeper than party feelings or sectional interests."

(In the preparation of the Address I have had the great advantage of consultation with my colleagues, Professors Cory, Dingemans, and Russouw; also with Mr. J. Hewitt, Director of the Albany Museum, the Rev. W. Y. St. George-Stead, and Miss Edwards, Lady Warden of Oriel House, Rhodes University College. These are all authorities upon different portions of the matters dealt with, but in no measure do they share any responsibility for the statements or views presented.)

STELLAR DISTANCES, MAGNITUDES AND MOVEMENTS.

By Joseph Lunt, D.Sc.,
Royal Observatory, Cape of Good Hope.

Presidential Address to Section A, delivered July 11, 1921.

Although Astronomy is the most ancient of all the sciences, it is only two hundred years ago—a mere matter of yesterday astronomically speaking—that Halley first discovered that certain of the brighter stars had perceptibly changed their positions with respect to neighbouring stars since they were recorded by Ptolemy in the Almagest from observations made nearly 2,000 years ago.

We now know that, just as Jupiter and Saturn with their attendant satellites move in their well-determined orbits round the sun—a phenomenon which must be seen to be fully appreciated—so our sun with all its attendant planets is hurtling through space at a speed twenty times as great as that of a modern rifle bullet, and that all the so-called "fixed stars," of which our sun is an example, are in rapid motion.

Thanks to the labours of generations of astronomers, who have accurately mapped the stars for us, we now see on either side of the sun's path and above and below it, a gradual but unmistakable drift of stars slowly filing past us as we proceed on our journey.

The spectroscope has revealed the further fact that the stars ahead of us are approaching and those behind are receding with velocities which—in the mean—are but a reflex of our own motion in space.

Astronomy has now, in common with most other sciences, become so complex that the recently-formed International Astronomical Union has found it necessary to divide it into no less than 32 sections, almost any one of which may easily provide enough material for a man's life-work. I need not, therefore, apologise for speaking about Astronomy again this year after the address given by my predecessor in office last year on the same subject.

In a short Presidential Address it is only possible to give an impressionist sketch of some of the main principles involved in a study of stellar distances, magnitudes and movements; details I must leave for your further reading.

In these studies, spectrographic methods are so essential that a brief survey of their development may come first.

Spectrographic Methods.

The birth of spectroscopy may be said to have taken place in 1666, when Newton first showed that the white light from the sun is really composed of seven different colours and that these colours could be re-combined to produce white light. It was, however, two hundred years later before the subject had been sufficiently advanced to make astronomical applications possible.

Wollaston (1802) and Fraunhofer (1814) made the next step by producing a purer spectrum by means of a slit, through which they passed sunlight, and they found the spectral band was crossed by numerous dark lines.

Fraunhofer mapped these lines, which now bear his name, and lettered the strongest of them A, B, C, D, etc., to K, but it was reserved for Kirchoff (1859) to explain the meaning of them.

Foucault in 1848 had indeed made the observation which is at the foundation of modern spectroscopy when he showed that the light from a powerful electric arc, when passed through a flame tinted yellow by the volatisation of a sodium salt and examined in a spectroscope, showed two black lines which were identical in position with the D lines which Fraunhofer had found in the sun. Sodium vapour absorbs just that particular light from a hotter source which it emits in a cooler source of light. The same is true of all other incandescent gases.

The vapour of incandescent iron, examined in the spectroscope, shows a very large number of emission or bright lines, and if this spectrum is placed alongside a solar spectrum it is seen that every line has a dark counterpart in the sun's spectrum. The same is true of other metals. Bunsen and Kirchoff made pioneer investigations into the spectra of many terrestrial substances and proved the presence of many of them in the sun.

The matter was followed up by Angström in 1868 when he published a map of the normal solar spectrum, in which the lines were given wave-lengths. Thalen extended the work by determining the wave-lengths of the spark spectra of all the metals then known and referring the values to Angström's normal map. The use of photographic methods enabled Rowland to produce much better maps and the wave-lengths of the solar lines in the visible region of the spectrum were put on a more satisfactory basis. Kirchoff's discovery of the meaning of the Fraunhofer lines in the sun's spectrum naturally led up to attempts to observe the spectra of stars.

Sir William Huggins with Dr. Miller, and Sir Norman Lockyer in England, Rutherford in America, Secchi in Italy, and Vogel in Germany were the pioneers in this "New Astronomy." In the words of Huggins: "The time was, indeed, one of strained expectation and of scientific exaltation for the astronomer, almost without parallel; for nearly every observation revealed a new fact, and almost every night's work was red-lettered by some discovery. And yet, nothwithstanding, we had to record that the enquiry in which we had been engaged has been more than usually toilsome; indeed it has demanded a sacrifice of time very great when compared with the amount of information we have been able to obtain."

Huggins' first observation of the spectrum of a nebula is of interest; he says: "Soon after the completion of the joint work of Dr. Miller and myself, and then working alone, I was fortunate in the early autumn of the same year (1864) to begin some observa-

tions in a region hitherto unexplored, and which, to this day (1897), remain associated in my memory with the profound awe which I felt on looking for the first time at that which no eye of man had seen, and which even the scientific imagination could not foreshow. The attempt seemed almost hopeless; for not only are the nebulae very faintly luminous—as Marius put it, 'like a rushlight shining through a horn'—but their feeble shining cannot be increased in brightness, as can be that of the stars, neither to the eye nor in the spectroscope by any optic tube, however great. The nature of these mysterious bodies was still an unread riddle. . . . . On the evening of August 29th, 1864, I directed the telescope for the first time to the planetary nebula in Draco. I looked into the spectroscope, no spectrum such as I expected! A single bright line only! . . . . A little closer looking showed two other bright lines on the side towards the blue, all the three lines being separated by intervals relatively dark. The riddle of the nebulae was solved. The answer, which had come to us in the light itself, read: Not an aggregation of stars, but a luminous gas."

The "New Astronomy," therefore, had its infancy during the life of the present generation; its growth has been phenomenally rapid, and at the present time no big telescope is planned without provision being made for spectrographic researches.

The work of the pioneers I have named has since been followed up by other workers, too numerous to mention individually. The spectra of all the terrestrial elements, under very diverse physical conditions, are still under investigation with ever-increasing precision, and the exact comparison of their lines with those of the stars and the sun is still going on. There are very many blanks in our knowledge still to fill up. The sun and the stars still show a host of lines in their spectra which have not been "fitted" to corresponding lines produced in our laboratories, and it may be that they never will be.

The highest temperatures to which we can attain in our experiments fall far short of those attained by the stars, and terrestrial spectra undergo such remarkable changes in passing from low to high temperatures that the complete elucidation of the spectra of all the elements we know, and all their spectral modifications under varied conditions, will still occupy the attention of experimentalists for very many years.

The stars and nebulae reveal the existence of substances which have so far never been discovered terrestrially, and there is still a large field unexplored, waiting for the chemist, the mineralogist, and the spectroscopist to investigate. Even in the spectrum of our own sun the gaps due to uninterpreted lines are very big ones, and no one knows the fascination of the problem until he has by experiment "fitted" terrestrially produced lines to "unknown" lines in celestial spectra.

Before the advent of spectroscopic methods the only movements of the stars which could be detected by the astronomer were those across the line of sight. The stars are so inconceivably distant that it requires the most minute accuracy of measurement to detect the motions at all. The "blink" method of comparing

star photographs taken about a quarter of a century ago with repeat photographs taken recently has made the detection of star movements across the line of sight much more certain and less laborious, and in the hands of Innes and Wood at the Union Observatory, Johannesburg, is yielding results of great value. Star movements in the radial lines from the observer to the star are in the peculiar domain of the spectroscopist. A star moving in a radial line away from us is lengthening its waves of light, and a star moving towards us is shortening them, just as the whistle of an express train is noticed to be higher in pitch when it is approaching us and lower when it is receding from us, so is the pitch or wave-length of light altered by motion.

An observer at a rock lighthouse will see the sea-waves passing him at a certain rate; a steamer going against the same incoming waves will meet more (or shorter) waves, and another steamer going with the waves will be overtaken by fewer (or longer) waves in a given time, than the stationary observer in the lighthouse.

This alteration of wave-length of light from its normal, due to motion either of the observer or the source, has the effect of shifting a line from its normal place in the spectrum, to the violet if the motion is one of approach and to the red if it is one of recession. The shift is microscopic, but accurate measurements easily show the oscillation of a star line to either side of its normal place, due to the motion of the earth in its orbit, and this shift has been used to determine the speed of the earth's motion and therefore the size of the earth's orbit and the distance of the sun. In the same way the motion of the sun in space manifests itself by the stars in one-half of the sky appearing, in the mean, to be approaching and those in the other half to be receding. The direction in which our solar system is travelling is now known with a fair degree of accuracy. Our observations of star movements in these radial lines must be corrected for the motions of the earth and sun before we can deal with the real movements of the stars themselves. These spectroscopically determined radial movements are expressed in kilometres per second, but the transverse movements (technically called "proper-motions") are expressed in seconds of arc per year or per century. The "proper motion" expressed in angular measure may be fast or slow, and we have no means of knowing which until the distance of the star concerned is known. When the distance is known, then we can convert seconds of arc into kilometres per second, and combining the radial and transverse motions expressed in the same units we can derive the real motions of the stars.

It is evident, therefore, that before we obtain a knowledge of the real motions of the stars we must know their distances, and when we know their distances we must, in order to compare their real magnitudes, bring them—in our calculations—to one common distance in order to compare them one with the other.

Star Magnitudes.

We shall see later that a knowledge of star distances leads to information about the absolute magnitudes of stars, and then

that a knowledge of absolute magnitudes is applied to the determination of the distances of stars too far remote for angular measurements. We must therefore as a next step consider star magnitudes. Ptolemy (A.D. 130) in the Almagest, divided the stars into six magnitudes; the brightest he called of first magnitude and the faintest visible to the naked eye he called the sixth magnitude, and this is the basis of our present classification. The relation between the brightness of two stars differing by one magnitude has now been defined as $\sqrt[5]{100}$ to 1 (log = 0·4), i.e., each succeeding magnitude is 2·512 times as faint as the preceding one. This figure, of which the logarithm is exactly 0·4, has been chosen so as to make a change of 5 magnitudes exactly a change of 100 times in brightness. On this exact scale some of the brighter stars are *more than* 100 times brighter than a standard sixth magnitude star and so the scale has to be extended from

$$+6. \quad +5 \ldots\ldots\ldots +1,\ 0,\ -1,\ -2,\ \text{etc.}$$

A star of zero magnitude is therefore one magnitude brighter than one of the first magnitude and a star of magnitude -1 is a magnitude brighter still. The "apparent magnitudes," as we see them, are not the real or "absolute magnitudes" because some stars are comparatively near us and some very distant.

The law of decrease of brightness with distance is, however, well known. The brightness varies inversely as the square of the distance.

Star Distances.

Distance is often expressed as the parallax, i.e., the angle contained between two lines from the star, one passing through the sun, and the other through the earth at greatest elongation as seen from the star.

No star is known to be near enough to have a parallax of one second of arc, which corresponds to the angle subtended by a foot-rule at a distance of forty miles. There are 1,296,000 seconds of arc in a circle. The unit commonly used in speaking of star distances is the "parsec," i.e., that distance at which a star must be to have a parallax of one second. The unit of distance for magnitude purposes is ten parsecs (parallax $=0{\cdot}1''$).

From this distance, light travelling at 186,000 miles a second takes 32·6 years to reach us. Distances are often given in "light-years." The following table shows the relationships we have been considering.

Table I.

Ratios of apparent magnitude, intensity and parallax for *the same star* at different distances:—

Apparent Magnitude	Intensity Ratios.	Distance Ratios.	Parallax ″	Distance in parsecs	Distance in light-years
−5	10,000,000,000	1	0·1	10	32·6
0	100,000,000	10	0·01	100	326
+5	1,000,000	100	0·001	1,000	3,260
+10	10,000	1,000	0·0001	10,000	32,600
+15	100	10,000	0·00001	100,000	326,000
+20	1	100,000	0·000001	1,000,000	3,260,000

Notes.—(1) The absolute magnitude of a star is defined as the apparent magnitude it would have if placed at the standard distance of 10 parsecs or 32·6 light years where the parallax would be 0·1″. The star in the above table is therefore of absolute magnitude -5 at all distances and whatever its apparent magnitude.

(2) Log distance factor $= 0{\cdot}2 \times$ (apparent mag.—absolute mag.).

(3) Distance in light years $=$ Distance ratio $\times 32{\cdot}6$.

(4) Parallax in seconds of arc $= \dfrac{3{\cdot}26}{\text{distance in light-years}}$.

(5) Parallax 0·1″ $\fallingdotseq$ 2,062,650 astronomical units.

(6) One astronomical unit $=$ approx. 93,000,000 miles.

Even the nearest stars are so remote that it is a matter of exceedingly delicate measurement to find their distances.

The first principle employed is the same as that used by surveyors in measuring the distance of a tree on the opposite bank of a broad river. Two stations are chosen at a measured distance apart, and sights are taken at both ends of the line. The angles between the lines and the length of the base-line give the distance. In the case of a star, no terrestrial base-line is big enough, and we have to use as base-line the diameter of the earth's orbit, 186,000,000 miles, and take sights from each end of a diameter six months apart, as we swing from one side of our orbit to the other. We are only now beginning to obtain these measures of distances in any number.

Forty years ago only about 20 such distances were measured, 20 years ago only about 60. These figures had increased to 200 in 1915, and now we have measured distances of about 900 stars, and the number may be expected to increase rapidly now that more instruments are in use for taking photographs for the purpose. This method, however, only enables us to measure the distances of the *nearest* of our stellar neighbours. For the vast majority of stars the angle subtended by 186,000,000 miles (twice the parallax) at the star is too small to be directly measured by any means at our command.

There are, however, other methods by which the distances of the stars, and therefore their absolute magnitudes, can be measured.

The sun in its journey through space is doing the same thing as the surveyor when measuring his base-line along the bank of a river; it is measuring out a base-line at the rate of nearly 400 million miles a year. In a century, therefore, the base-line will be over 200 times as long as the diameter of the earth's orbit. It is evident, then, that it is of the utmost importance to secure photographs of the stars at the present time on a sufficiently large scale to show changes of relative position when compared with photographs to be taken a century hence. *It is a debt we owe to posterity.* Comparisons can now be made with photographs taken a quarter of a century ago for the detection of this "parallactic

drift'' of the stars. It is evident that the nearer the star, the greater will be the ''drift'' just as in travelling by rail through a forest, the nearest trees appear to move fastest and the distant trees slowly. The measurement of a star's distance by its apparent cross motion is, however, complicated by the fact that *all* the stars are moving and the disentangling of the parallactic drift and the peculiar motions of the stars is a matter of some difficulty.

Another important advance has been made by Professor Adams, of Mount Wilson Observatory. He has found by a careful examination of the spectra of stars of known distance—and therefore known absolute magnitude—that if these stars are arranged in order of absolute magnitude then the spectra also fall into a regular sequence. It is, therefore, only necessary to examine the spectrum of a star and find its position in this sequence to find its absolute magnitude, and by comparing this with its apparent magnitude the distance of the star is found.

Prof. Adams and his associates have just published (January, 1921) a list of the parallaxes of 1,646 stars derived by this spectrographic method. It is important to note that the actual distance of the star is no obstacle in this method as no angular displacement has to be measured. This list contains stars with parallaxes as low as 0·001″ equivalent to a distance of 3,260 light years, and yet these stars, being bright enough to yield a spectrum, must be counted as among the nearer stars. This method fails when a star is too faint to yield a spectrum in our most powerful instruments, but we are not without other methods of ascertaining something about a star's spectrum even when the spectrograph fails. We have now to fall back on the colours of stars as a guide to their actual spectra. The eye and the ordinary photographic plate are most sensitive to different regions of the spectrum. The maximum sensitiveness of the eye is to rays in the yellow and green region, whilst the photographic plate ''sees'' best in the blue and violet. Stars rich in blue and violet rays therefore appear brighter in star photographs, and red stars appear fainter than we actually see them. The sequence of star spectra corresponds to the sequence of colour, and we have a regular gradation from the bluest stars to the reddest stars.

By the use of suitable colour-sensitive plates and absorbent screens we can obtain photographs of stars much as we see them as regards relative magnitude. The magnitudes thus obtained are called ''photo-visual'' magnitudes, and by comparing these with the photographic magnitudes we obtain an index—the ''colour index''—to the star's spectrum, and therefore its absolute magnitude, and by comparison with its apparent magnitude, its distance

Another very important method of finding a star's distance has recently been developed by Dr. Harlow Shapley, also at Mount Wilson, which can be applied to stars so faint that the spectrographic method fails.

Certain short-period fluctuations in the brightness of giant stars of high luminosity have been carefully investigated and found to be peculiar to these stars. A relation between the period of the

fluctuations and the absolute magnitude has been found. If, therefore, a very faint star in a very distant star cluster exhibits these light variations, the period of the variability can be used for placing the star in its proper position in the absolute magnitude scale.

In a series of remarkable and brilliant papers Dr. Shapley has pursued this and kindred methods very thoroughly in order to find the distance of globular star clusters, and concludes that the brightest stars in them correspond to the giant stars of greatest luminosity which are found in our local star field.

The distances he derives for the globular clusters vary from 20,000 to 200,000 light years. The light from the farthest cluster must therefore have been on its way 180,000 years earlier—and the cluster as we now see it is that much younger—than the light from the nearer cluster in order to arrive at the earth at the same time. If we can assume that the clusters are of the same age then we can say that 180,000 years makes little difference in the appearance of a star cluster, as except for its smaller size and fainter stars—which are merely the effect of greater distance—the clusters look much alike. Considerations such as these bring home to us the immensities of space and the eons upon eons of time we must allow for the evolution of stellar systems. It seems probable that the distances separating the individual stars in the nucleus of a cluster, where they appear so crowded together as to be almost irresolvable, is much the same as the distances separating us from the bright stars we know in our immediate vicinity.

Dr. Shapley concludes that the diameter of the cluster Messier No. 3 is such that light would take 470 years to traverse it, and light travels at the rate of 186,000 miles *a second;* its distance he concludes to be of the order of 250,000 million million miles (13,900 parsecs or 45,000 light years) equivalent to a parallax of 0·000072″, and this is one of the nearer clusters! The most remote cluster known is about five times as far away.

There is still another method of estimating the distances of remote stars. From time to time bright stars suddenly appear in the sky in places where no bright star was previously seen. These are called "blaze stars" or "Novae"; they appear to be due to some tremendous cataclysm which causes the star to burst into flame with explosive violence, so violent that the star is transformed into a gaseous nebula and subsides into a faint object very rapidly. When these "blaze stars" appear in the milky way they are comparatively near to us, and appear sometimes as bright as Sirius, the brightest star in the sky. The distances of some of these have been measured, and from their known distances and apparent magnitudes their absolute magnitudes have been found. At the standard distance of 32·6 light years they would appear as bright as Venus at maximum brilliancy and would easily be seen in full sunshine.

The bright Nova in Aquila, which Mr. Watson, of Beaufort West, was one of the first to discover three years ago, attained an absolute magnitude of $-4{\cdot}9$, a figure arrived at from trigono-

metrical measures of its distance, 155 light years (which means that the outburst occurred in 1763 and we only perceived it in 1918), and its apparent maximum magnitude $-1{\cdot}5$.

Many Novae have been discovered photographically in the great nebula in Andromeda; they have usually attained the 17th magnitude. If we can assume that they are comparable in brilliance to the one in Aquila, we have a difference of apparent magnitude $-1{\cdot}5$ to $17{\cdot}0 = 18{\cdot}5$, which, from the known laws connecting apparent magnitude and distance, corresponds to a distance 5,000 times as great as the one in Aquila or 775,000 light years. We conclude therefore that the great nebula in Andromeda is in round numbers 800,000 light years distant.

This is the same figure as that derived for some spiral nebulae by Aitken by similar reasoning from more extensive data concerning Novae in spirals and in the Milky Way.

It must be understood that in speaking of the distances of the remoter stars, a few million miles or even a few light years are but as the dust of the balance.

Very many of the stars which to the unaided eye appear single are seen to be double when examined telescopically.

In very many cases the two stars are physically connected, as each of them revolves round their common centre of gravity. Alpha Centauri, our nearest stellar neighbour, is a familiar example; it may be seen to revolve even in small telescopes. The period of revolution is a little over 81 years, whilst other pairs take hundreds of years to perform a revolution. Alpha Centauri is so near that the angular distance apart of the two components varies from $22''$ to less than $2''$ during a revolution. More distant binary stars appear as closer doubles, and, for a given absolute separation, beyond a certain limiting distance the two stars cannot be separated by the most powerful telescopes.

Where the telescope fails the spectroscope is still able to prove that a star apparently single is in reality double, or even triple, the revolution of the two stars round their common centre of gravity being shown by the oscillation of the lines of the spectra about their normal positions.

Knowing the speed, from the measured displacement, and the time taken to make a complete revolution, the minimum dimensions of the system can be determined. If the plane of the orbit is at right angles to the line of sight, the spectroscope cannot detect the rotation, as there is no motion of approach or recession, but if the orbit contains the line of sight, the spectroscopic orbital velocities reach their full value. In this case one star eclipses the other at every revolution, and we have a more or less sudden drop in the brightness. Stars showing this phenomenon are known as eclipsing binaries or Algol variables, the star Algol being the type star, showing a drop in brightness every 2·867 days. At intermediate inclinations of the orbits the spectroscopic velocities of rotation are only a fraction of the real ones, proportional to the *sine* of the angle of inclination, and we have no means of knowing the actual size of the orbits unless the binary is near enough for

us to measure the system as a double star, and so determine the inclination. From these combined observations of real dimensions and apparent size we can find the distance of the pair. The period of revolution varies enormously, from a few years to hundreds of years in the case of visual binaries, and from a few years to a few days, or even a fraction of a day, in the case of spectroscopic binaries.

The actual dimensions of the systems also vary enormously. In the case of spectroscopic binaries of very short period of revolution it is difficult to believe that two separate stars are involved at all, and it is thought that pulsations or alternate expansions and contractions in a single diffuse gaseous star may give rise to the observed oscillations of the lines of the spectrum. From this pulsating stage we may pass to pairs of stars revolving in contact and then to pairs becoming wider and wider apart as they attain greater age and later types of spectrum. Aitken concludes that "at least one in every eighteen, on the average, of the stars in the northern half of the sky which are as bright as the ninth magnitude is a close double star visible with the Lick thirty-six inch refractor," whilst Campbell states that at least one star in three, on the average, of very early type stars is a spectroscopic binary, and of the middle and later types one star in six is a binary. There is still another method of determining a star's distance. It depends on the possibility of measuring the position angle and distance apart of the components of a double star (of known spectroscopic orbit), which is too remote to be perceived as double in our most powerful telescopes. Michaelson has devised a method of making these measurements by the use of an interferometer, and Anderson has applied the method to Capella.

The value of Michaelson's method lies in the fact that we can extend our measurements much further into space, and deal with stars which could not be reached by ordinary micrometrical methods. Experiments in this direction are now being made at Mount Wilson with the 100-inch telescope. In the light of the foregoing information we can now compile a short list of stars to illustrate the fact that the stars differ enormously in absolute magnitude, the range in intensity being *at least* from 100,000,000 to 1, our own sun occupying a middle place between the brightest star (10,000 times brighter) and the faintest star 10,000 times fainter (see Table II.). Dr. Shapley concludes that if we could place our sun amongst the stars of the Hercules cluster (Messier No. 13) it would appear fainter than the 22nd magnitude, which means that it would be absolutely invisible in the 100-inch reflector at Mount Wilson, the most powerful telescope in the world, and it would be in company with thousands upon thousands of stars of so much greater brilliancy that they could easily be seen in a small telescope. No star as faint as our sun has yet been photographed in this cluster, and all the stars in it which he has catalogued are more than 200 times as bright. Our brightest star Sirius, apparent magnitude $-1{\cdot}6$, placed at the distance of M13 would appear fainter than the 18th magnitude.

Problems and Needs of Modern Astronomy.

The great problem of Astronomy to-day is to unravel the structure of the starry heavens, to determine the distances of its component parts and their mutual relationships and movements, and the forces at work producing these movements; to trace the life history of the individual stars, the compositions of their atmospheres, and the changes which take place in them.

Let us turn now, for a few moments, to the more human side of Astronomy.

So recently as 1832, Prof. Airy, afterwards Astronomer Royal of England, made a Report to the British Association on the condition of practical Astronomy in various countries. In this Report he remarked that he was unable to say anything about American Astronomy because, so far as he knew, no public observatory existed in the United States. And yet, to-day, the foremost country in the world, as regards the advancement of astronomical knowledge, is undoubtedly the United States of America. The reasons are not far to seek. In America a knowledge of Astronomy is regarded as a necessary part of a liberal education. Many colleges and the Universities are disseminating astronomical knowledge and making astronomy a popular study, which is further encouraged by opportunities of a real study of the heavens at the telescope and by lectures and meetings at numerous centres throughout the country.

There are many opportunities for post-graduate study at the larger observatories, and some of the students develop a taste for Astronomy which grows into an enthusiasm sufficient to decide them to make it their life's work.

Newcomb says: "In all ages Astronomy has been an index to the civilisation of the people who cultivated it. It has been crude or exact, enlightened or mixed with superstition, according to the current mode of thought. When once men understand the relation of the planet on which they dwell to the universe at large, superstition is doomed to speedy extinction. This alone is an object worth more than money. . . . Prof. O. M. Mitchell, the founder and the first Director of the Cincinnati Observatory, made the masses of our intelligent people acquainted with the leading facts of Astronomy by courses of lectures which, in lucidity and eloquence, have never been excelled. The immediate object of the lectures was to raise funds for establishing his observatory and fitting it out with a fine telescope.

"The popular interest thus excited in the science had an important effect in leading the public to support astronomical research. If public support, based on public interest, is what has made the present fabric of American astronomy possible, then should we honour the name of a man whose enthusiasm leavened the masses of his countrymen with interest in our science."

The American people have not depended on their Government to provide them with the means of carrying out their studies in Astronomy, they have found the means themselves.

In 1874 Mr. James Lick gave 700,000 dollars to provide a telescope superior to and more powerful than any telescope yet made and also a suitable observatory connected therewith. The regents of the University of California are the trustees of this bequest. In 1892 Mr. Charles T. Yerkes, of Chicago, offered to purchase a pair of discs of optical glass, 42 inches in diameter, for the University of Chicago, and to bear the entire cost of building an equatorial refractor of 40 inches diameter and housing it in a suitable observatory.

Five years later saw the dedication of the Yerkes Observatory, 75 miles from Chicago, on Williams Bay, Lake Geneva. The telescope is still the largest refractor engaged in astronomical research. Ample preparation for advanced studies in theoretical and practical astronomy and in astrophysics is afforded by the courses at the University of Chicago. After completing the necessary preliminary work at Chicago, students who desire to devote special attention to observational astronomy or to astrophysics are admitted to the Yerkes Observatory, where they are given every possible facility, and as soon as they have had sufficient preliminary training they are encouraged to undertake original investigations of their own. Similar facilities are given at Berkeley in connection with the Lick Observatory. The great need of the astronomer is more and more light, and although the 40-inch refractor marked a high level in light-gathering power, it was not sufficient to meet the demand for more. A refractor, too, suffers from the great disadvantage of not being able to bring all the light from a star to one focus. Visitors to a big telescope are much impressed by the violet halo which they see round a bright star—a halo which the astronomer mentally ignores—caused by the out-of-focus violet image. In a photographic refractor the halo is red, centred with green, when the focus is adjusted for the most active photographic rays. These differences in focus for different parts of the spectrum are inseparable from the use of a refractor and are of great disadvantage in work on stellar spectra. The reflector, on the other hand, reflects all colours impartially and brings all to one common focus on the slit of the spectroscope or on the photographic plate.

To meet the need of a big reflector, Mr. John D. Hooker, of Los Angeles, California, in 1906 gave 45,000 dollars for the purchase of a glass disc 100 inches in diameter to be made into a reflector for the Mount Wilson Observatory. The making of such a disc of glass free from flaws is a very difficult matter, and the first disc made was considered so faulty that it was rejected at sight. So many difficulties arose, ending in failure to produce a better one, that the first disc was ground to shape, polished and tried, and the result was quite successful.

The mounting of such a large mirror and the transport to Mount Wilson of all the necessary accessories to such a large telescope was a serious engineering problem, but the combined thought and skill of many men resulted after eleven years of work in the successful accomplishment in 1917 of the great project. In

announcing Mr. Hooker's gift of money for the 100-inch mirror Prof. Hale stated that "no provision has yet been made for the mounting and dome. It is not known from what source funds for this purpose will come, but I believe a donor will be found by the time they are needed." Prof. Hale's optimism proved to be quite justified. Money for the mounting and dome, and all other necessary accessories, materialised in due course.

Perrine states that the new mounting of the 36-inch Crossley reflector of the Lick Observatory was only made possible through the generous gifts of a lady, Miss Phoebe A. Hearst. The mirror itself was made by Dr. Common, of London. It was presented to the Lick Observatory by Mr. Crossley, of Halifax, England, and was at that time (1900) the largest instrument of its class in America. The funds for transporting the telescope and dome to California and setting them up on Mount Hamilton were subscribed by friends of the Lick Observatory, for the most part citizens of California.

Many other names might be mentioned of men and women who have made magnificent gifts for the furtherance of Astronomy, such as Mr. D. O. Mills, who most generously offered to provide funds for constructing instruments, for defraying travelling, erecting, and maintaining expenses, and for the salaries of the astronomers engaged in an expedition to the Southern Hemisphere in connection with the Lick Observatory. This expedition established a 36½ inch reflector in a suitable observatory on a hill in the suburbs of Santiago, Chile, in October, 1903, and it has done most valuable work.

Miss Catherine W. Bruce, of New York, who had done so much already for the advancement of Astronomy, placed 7,000 dollars in the hands of Prof. Barnard, in 1897, as a gift to the University of Chicago, for the purpose of erecting a wide angle photographic telescope and a suitable building at the Yerkes Observatory. Miss Bruce had previously provided a 24-inch doublet and object glass prism for the Harvard College Observatory's southern station at Arequipa in 1896. Miss Helen E. Snow, of Chicago, is another lady donor. The "Snow Horizontal Telescope," her gift to the Yerkes Observatory in memory of her father, was afterwards transferred to Mount Wilson.

This list might be much extended, but time and space forbid. It is sufficient to show one of the reasons why the United States is in the forefront as regards the advancement of astronomical knowledge to-day. Canada has recently completed a 72-inch reflector and built the Dominion Astrophysical Observatory at Victoria, British Columbia. The telescope is provided with a full spectrographic equipment, and is already doing excellent work on binary stars. This observatory is an offshoot from the one at Ottawa, and it is interesting to learn that—as at the Lick Observatory—it is thought worth while to devote Saturday evenings in each week to the public. Visitors are then allowed to see some of the glories of the heavens through this giant telescope. Some, possibly, will ultimately become enthusiastic enough to take up the

work seriously and some may become the donors of the telescopes of the future.

Newcomb has said that "it is only when men are relieved from the necessity of devoting all their energies to the immediate wants of life that they can lead intellectual lives."

We have heard a great deal recently about the status of South Africa. The status of South Africa cannot be measured by its material wealth and prosperity, but we may measure it rather by the number of men and women it possesses who are enabled to lead intellectual lives by their devotion to pure science—quite apart from its technical or economic applications—to painting, music, poetry, and the arts generally. South Africa is at the threshold of great University development, and now is the time to consider what part they shall play in the future development of astronomical and astrophysical research in the Southern Hemisphere.

We, in South Africa, are privileged to have stretched before us every night a vista of stars which cannot be seen from the great northern observatories, and the study of the southern skies is a necessary complement to that of the northern skies. Are we to do our part in reading the pages of the great book stretched before us, or shall we wait until northern observatories establish offshoots in our country to read the riddles of the heavens for us? The answer depends largely on our Universities and on our rich men and women. Will those possessed of surplus wealth devote it to the intellectual development of South Africans, or will they take it away to spend on their own pleasures? The largest telescope we have in South Africa, the gift of the late Mr. Frank McClean, of Tunbridge Wells, England, is now a quarter of a century old, and in size and light-gathering power is quite inadequate to attack many problems which now face the astronomer. Even if we had a Mr. Hooker at this moment to donate a sum of money for a big glass disc, and others to follow with donations for a mounting and an observatory, it would be many years before the instrument could be completed, and what of the men to use it? Are our Universities fostering an interest in the grandest of all sciences and training men to take advantage of the opportunity should it come to us? If the donors could be found, I should like to see each of our Universities provided, as a beginning, with a six-inch clock-driven equatorial telescope and a star camera, for the use of our students and to encourage them to take a broad outlook on life and on Nature. When we come to consider the earth in its relation to our solar system and our solar system in its relation to the universe we must stand in awe and reverence, but when we consider the myriad forms of life on this speck of dust we call our earth, when we look for example at the marvellous beauty, mechanism, and structure of a butterfly or a flower and how they develop from a tiny egg or a seed, in a way we cannot fathom, we must see that, throughout all, there is something divine. Although man, with his mental and spiritual attributes, transcends every other living

creature, above man there must be some power and some divine artist just as immeasurably transcending man.

Table II

Comparison of the sun with other stars, and examples of absolute and apparent magnitudes and distances:—

	Absolute Mag. (M)	Apparent Mag. (m)	Parallax π ″	Distance in light-years §
Novae in Andromeda nebula	− 4·9*	+ 17·0	0·000004	780,000
Brightest star in M13	− 5·7	+ 11·9	0·000030†	109,000
Bright stars in NGC 7006...	− 1·5	+ 17·6	0·000015†	217,400
Bright stars in ω Centauri (NGC 5139)	− 1·5	+ 12·6	0·000150†	21,740
58 Persei	− 4·2	+ 4·5	0·002	1,630
α Ursa Minoris	− 3·0	+ 2·1	0·010	326
Nova Aquilae No. 3 (maxm.)	− 4·9	− 1·5	0·021‡	155
Nova Persei No. 2 (maxm.)	− 4·4	0·0	0·013‡	250
Canopus	− 3·0	− 0·9	0·038	86
Venus at maxm. (March, 1921)	+ 29·0	− 4·3	——	——
α^1 Herculis	− 2·3	+ 3·5	0·007	466
ϵ Aurigae	− 2·0	+ 3·4	0·008	408
β Herculis	− 1·0	+ 2·8	0·017	192
β Pegasi	0·0	+ 2·6	0·030	109
α Hydrae	+ 0·1	+ 2·2	0·038	86
α Tauri	+ 1·0	+ 1·1	0·096	34
Sirius	+ 1·3	− 1·6	0·376	8
β Geminorum	+ 1·7	+ 1·2	0·126	26
α Canis Minoris	+ 3·2	+ 0·5	0·347	9
α^1 Centauri	+ 4·8	+ 0·3	0·794	4·11
The Sun	+ 4·8	− 26·5	——	——
Boss 2199	+ 6·2	+ 6·0	0·110	30
Boss C 594	+ 8·5	+ 8·5	0·100	32·6
Boss C 1244	+ 10·5	+ 9·2	0·182	18
Barnard's proper motion* ...	+ 13·3	+ 9·7	0·52	6·27
Innes's proper motion*	+ 15·4	+ 11·0	0·784	4·16

Note. $5 \log \pi = M - m - 5$. $M = m + 5 + 5 \log \pi$.

* Assumed equal to Nova Aquilæ No. 3 at Maximum.
† Assumed correct. ‡ Measured parallax.
§ A light year = 5·9 million million miles.
A parsec = 19·2 ,, ,, ,,
Parallax 0.1 {= 192 ,, ,, ,,
{= 2,062,650 Astronomical units.

BIBLIOGRAPHY.

"Problems in Astrophysics," by Agnes M. Clerke, A. & C. Black.
"The System of the Stars," by Agnes M. Clerke, A. & C. Black.
"Stellar Motions," by W. W. Campbell, Yale University Press.
"The Binary Stars," by Robert G. Aitken, McMurtrie, New York.
"The Study of Stellar Evolution," by Geo. Ellery Hale, University Chicago Press.
"Stellar Movements and the Structure of the Universe," by A. S. Eddington, Macmillan & Co.

CURRENT LITERATURE.

Publications Astronomical Society of the Pacific.
Journal of the Royal Astronomical Society, Canada.
Journal of the British Astronomical Association.
Astrophysical Journal.
Monthly Notices, Royal Astronomical Society.
Mount Wilson Contributions to the Carnegie Institution of Washington.

THE ATOMIC THEORY IN 1921.

By JAMES MOIR, M.A., D.Sc., F.R.S.S.A., F.I.C., F.C.S.,
Government Mining Chemist.

With Plate I.

Presidential Address to Section B, delivered July 12, 1921.

In thanking you for the honour of being elected President of this Section I take the opportunity of explaining why I deviate from the customary rule that a Presidential Address should not resemble an ordinary scientific paper but should be of more general interest, in fact not unlike a popular science lecture. The fact is, however, that in the five years since I last wrote a Presidential Address there has been such a tremendous upheaval of the foundations of Chemistry and Physics that it is desirable that someone should take the trouble to assimilate the new views and put them on record in a connected form for the use of South African scientists. This must be my excuse for not attempting the usual kind of address—which might be crystallised in the phrase "Science for Stockbrokers."

The revolution which has taken place is one of very great philosophical interest, and is, briefly speaking, the reduction of Chemistry to a branch of Physics. This has taken place in three logical steps, the first being the recognition of the fact that all chemical properties of a compound can be explained by the number and the arrangement of the *chemical valencies* of the different

elements contained in the compound. All chemical properties are thus referred to the properties of the 92 chemical elements, with the addition of special phenomena solely connected with the *arrangement* of elements among one another.

The second step is the Periodic Law of the elements, whereby the 92 elements are shown to have only about 10 different kinds of valency amongst them. The model atom was invented to explain this. It consists of a hollow sphere containing a minute heavy kernel* with a *distant* ring or shell of electrons, each of which gives a valency; the shell may consist of any number of electrons between 1 and 10, the number and arrangement thus explaining all the possible kinds of valency, and therefore all the strictly chemical properties.

The third step consists in showing that the remaining (non-chemical) properties of the atom, such as weight, depend on the nature of the atom-nucleus. The nucleus of certain familiar chemical elements has recently been broken down by artificial means, thus showing that the atom is not the indivisible minute sphere that it was supposed to be in the 19th century, but is itself a compound of smaller bodies in a special arrangement. Nitrogen, for example, is shown to consist of 4 particles of weight 3 along with two hydrogen atoms, each being characteristically charged with positive electricity and the whole being held together by "binding negative electrons" to give mass 14 and charge 5. The particle of mass 3 itself is also almost certainly a combination of 3 hydrogens and an electron. Chemistry and Physics therefore now depend on two substances only, instead of, as before, on the 92 elements of the Chemist.

The fundamental conceptions of the new atomic theory are those connected with hydrogen in its three forms, viz.: (1) hydrogen-ion (hydrion), the cause of acidity, (2) nascent hydrogen, and (3) free hydrogen gas.

A. Hydrion is the fundamental and only weight-substance: it consists of unit weight accompanied by unit positive electricity ($=1^+$), and all the elements, following Prout's hypothesis of 100 years ago, are associations of hydrion with electrons ($=0^-$) in different numbers and arrangements. The function of the innermost electrons is to hold the hydrions together, and this the electrons can do even if they are less in number than the hydrions. This combination of a number of hydrions with a *smaller* number of electrons constitutes an *atomic nucleus*, which thus possesses a positive electric charge equal to the difference between the numbers of hydrions and electrons present. Thus the nucleus of the element lithium is conceived to consist of seven hydrions held together by four electrons, and this nucleus therefore behaves as possessing 7 units of weight† and 3 positive charges. It is to be noted that the size of the hydrion is somewhat smaller than that of the electron, the diameter of which is 4 x 10^{-13} cm.

---

* The difference between kernel and nucleus is defined later on.

† The electron (or unit negative electric charge) is assumed to be weightless: it is in fact $\frac{1}{1850}$ of hydrion.

B. Nascent hydrogen in this system is merely atomic as opposed to molecular hydrogen, i.e., it is half of whatever molecular hydrogen (hydrogen gas) is conceived to be. Consequently it will clear matters up if we consider a simple case, such as that of adding sodium-amalgam (containing very little sodium) to a solution of ferric chloride. In the first half of the action, assuming sufficient dissociation of the water, nascent hydrogen is formed according to the equation, which used to be written:—

$NaHg$	+	H^{+}	+	$OH^{\prime}$	=	$Na^{\cdot}$	+	Hg	+	H	+	$OH^{\prime}$
Neutral Metal		Hydrion		Hydroxidion		Sodium ion		Neutral Metal		"nascent"		Hydroxidion

Similarly the second equation, according to the former dispensation, was:—

H	+	$Fe^{\cdot\cdot\cdot}$	=	H^{+}	+	$Fe^{\cdot\cdot}$
Nascent, neutral pseudometallic		Ferric ion		hydrion		ferrous ion

Now on the modern theory, hydrion is the absolute proton or fundamental unit of matter, and its positive charge is inherent in it and inseparable from it. It follows therefore that "nascent hydrogen" is not *uncharged* H, but is *neutral*, viz., $H^{+\prime}$, i.e., hydrion with an electron joined to it. (See Fig. 1.) In order, therefore, to be able to re-write the first equation in the modern way, we must provide an electron, and the equation becomes:—

$NaHg^{\cdot\prime}$	+	H^{+}	=	$Na^{\cdot}$	+	Hg	+	$H^{+\prime}$
Metal Neutral		Hydrion		Sodium ion				nascent or atomic

The second equation then becomes:—

$$H^{+\prime} + Fe^{\cdot\cdot\cdot} = H^{+} + Fe^{\cdot\cdot\cdot\prime} = H^{+} + Fe^{\cdot\cdot}$$

With regard to the last step it is to be remembered that 3 dots means a majority of 3 positive charges: the addition of the (negative) electron reduces the majority to 2. The dots used for positive valency thus merely mean shortage of electrons.

C. Hydrogen gas or molecular hydrogen is known from its Cp/Cv ratio to have a long molecule, far removed from roundness, and since it results from "nascent hydrogen" without addition or subtraction of electricity, its formula must be $(H^{+\prime})_2$, viz. $(H^{+\prime\prime}H^{+})$, i.e., it consists of two pairs of entities, one being hydrion and the other the electron. Now the spatial arrangement of these 4 things cannot be square or tetrahedral, otherwise the molecule would not be "long." It must therefore be either a straight line or a narrow-diamond-shaped figure, viz., either $(H^{+\prime\prime}H^{+})$ or $(H^{+}{}^{\prime}_{\prime}H^{+})$.

We now meet with the chemical fact that lithium hydride exists and that it is at first glance composed of two positive substances Li and H, which is impossible owing to electrical repulsion. Further, in both the above formulations of hydrogen gas the electrons are close together, which also is contrary to hypothesis since both are negative and would repel one another. Lithium

hydride is a salt-like non-metallic material made from lithium metal and hydrogen gas, both of which are electrically *neutral* (not positive): we must therefore assume the equation $Li^{\cdot\prime} + H^{+\prime} = (Li^{\cdot} \,{}_{\prime}^{\prime}\, H^{+})$ in which the arrangement of the electrons is the same as in hydrogen gas. It is stated, however, that when LiH is melted and electrolysed, lithium metal appears at the kathode and hydrogen gas at the *anode*.* Now the kathode is negative, hence the appearance of lithium metal $(Li^{\cdot\prime})$ is normal, but at the anode we must assume that $(H^{+})^{\prime\prime}$ forms a *negative* ion attracted there, and that it then loses an electron to the positive anode, giving $H^{+\prime}$ which is nascent hydrogen. We are thus again led to the assumption that hydrogen gas consists of the positive (H^{+}) joined to the negative $(H^{+})^{\prime\prime}$. The only possible reconciliation of all the facts is to assume that $(H^{+})^{\prime\prime}$ has not got its electrons close together. Thus hydrogen gas is $(H^{+} \xrightarrow{\text{at a distance}} H^{+})$ with $\prime$ above and $\prime$ below the final H^{+}. (See Fig. 2.) Some writers get over the difficulty by dissecting the electron itself into a repulsive electric part and an attractive magnetic part, but this is at present scarcely credible. Similarly in methane and other inactive hydrogen compounds one has to assume that carbon parts with 4 electrons to 4 neutral H atoms giving 4 distant $(H^{+})^{\prime\prime}$ groups round the carbon kernel; whereas on the contrary in a hydrogen-compound which is a tetrabasic acid (e.g., $H_4Si\ O_4$) the hydrogen outside consists of plain hydrions (H^{+}) and the 8 electrons left over are pushed inside close to the kernel, thus $(H^{+})_2$———$SiO_4{}^{\prime\prime\prime\prime\prime\prime\prime\prime}$———$(H^{+})_2$.

Having now dealt fully with hydrogen in its different phases let us now consider what is the nature of another simple monovalent element. Taking lithium as the simplest case, we remember that we have arrived at the conclusion that it consists of a small nucleus composed of 7 hydrions held together by 4 electrons, giving a total positive nucleus charge of 3. Since lithium *metal* is neutral, and lithium in the ionised state positively monovalent, we see that the nucleus must carry two negative electrons just outside it. This combination of nucleus and close electrons is called the "kernel" of the atom. The "kernel" is the same as the "ion" when there are not many outside electrons. Thus lithium *ion* $Li^{\cdot}$ is $\theta(4H^{+} + 4\theta + 3H^{+})\theta$, in which θ is the electron. It has 7 plus and 6 minus charges, therefore has +1 valency. (See Fig. 3.) Lithium *metal* is the foregoing $Li^{\cdot}$ with a seventh electron at a comparatively great distance, viz., $[\theta(4H^{+}4\theta\ 3H^{+})\theta\ \ \theta]$ making it electrically neutral. Now the number 3 in the case of lithium, which is both the nuclear charge and the total of the number of *external* electrons (in this case 2 + 1) coincides with the fact that in the Periodic Law as ordinarily written lithium is the third element in order. Similarly beryllium, the fourth element in the ordinary Periodic Law, has a

* Hydrogen appears at the kathode in the electrolysis of water, etc.

nuclear charge of 4 and a total of 4 external electrons. (See Fig. 4.)

Sodium is 8 places higher than lithium, therefore has a nuclear charge of 11 (3 + 8) and 11 external electrons. The nuclear charge of + 11 is the difference between 23 hydrions (giving the weight) and 12 electrons; and as regards the eleven external electrons it is assumed that 10 of them are close to the nucleus, forming along with the nucleus the "Kernel" (or "ion") of sodium. Thus $Na^{\cdot}$ (the ion) is $5\theta(12H^{+}\ 12\theta\ 11H^{+})5\theta$, and sodium *metal* is this kernel with a separate electron at a greater distance, as in the case of lithium. In order to bring out the complete analogy between sodium and lithium it is assumed that the 10 external electrons are arranged so that 2 of them are just outside the nucleus and the other 8 are about twice as far away, all equidistant from the centre and therefore arranged something like the 8 corners of a cube round the nucleus. This arrangement of 8 electrons, the conception of which is due to Gilbert Lewis, and which is technically called a "completed octet," is assumed from its perfect symmetry to confer chemical inertness, and as a matter of fact sodium ion, except towards electricity, is quite as inert as argon, going through all sorts of chemical actions unchanged. Similarly potassium ion $K^{\cdot}$ is $9\theta(20H^{+}20\theta\ 19H^{+})9\theta$, in which the nucleus with 19 plus charges (potassium is 8 above sodium, i.e., is the 19th element) has 18 external electrons, viz., the arrangement of 10 which exists in sodium, along with another "completed octet," thus giving again a kernel or ion which has no projections and is therefore inert.

When we come to the next member rubidium we find that the atomic weight is no longer twice the atomic number plus one as it is in the case of lithium, sodium and potassium. Rubidium ion $Rb^{\cdot}$ is $18\theta(48H^{+}48\theta\ 37H^{+})18\theta$ in which the nucleus contains 10 more hydrions and electrons than would have been expected from the lower members: the nuclear charge is 37, and there are 36 external electrons, arranged counting from the inside as before as 2, 8, 8, 18. Irving Langmuir (*J. Amer. C.S.* 1919, 879) suggests that the external 18 are arranged not like the internal 18 (*viz.*, as 2, 8, 8) but by uniform distribution over a spherical surface, *viz.*, two polar and 8 in each of two zones round the equator. This again gives a surface without projections or lacunae, and corresponds to the inertness of the rubidium ion. Similarly $Cs^{\cdot}$ (caesium ion) is $27\theta(78H^{+}78\theta\ 55H^{+})27\theta$, with weight 133, nuclear charge 55, and 54 external electrons arranged 2, 8, 8, 18, 18. The top member (which is unknown) "ekacaesium" (it lies between niton and radium) would have the structure $43\theta(136H^{+}136\theta\ 87H^{+})43\theta$, with external electrons arranged 2, 8, 8, 18, 18, 32. This arrangement of the electrons in concentric layers finds its origin in Rydberg's remarkable observation that the atomic numbers of helium, neon, argon, krypton, xenon and niton (*viz.*, 2, 10, 18, 36, 54, and 86) which are also the numbers of external electrons in the ions of lithium, sodium, potassium, rubidium, caesium and ekacaesium, are given by the mathematical formula $N = 2\ (1^2 + 2^2 + 2^2 + 3^2 + 3^2 + 4^2$, etc.) e.g., $36 = 2(1^2 + 2^2 + 2^2 + 3^2)$ for the fourth member. This at once gives

the distribution in the concentric shells as 2, 8, 8, 18, 18, 32, 32. Langmuir gives this a physical basis by noting that areas of concentric spheres of radius 1, 2, 3, 4, 5 vary in the same proportion as the numbers 2, 8, 18, 32, 50. He therefore assumes that these higher atoms have spheres of radius 1, 2, 3, and 4, and that there are two electrons in each unit of area in every sphere except the innermost, thus giving the numbers 2, 8, 8, 18, 18, 32, 32, it being assumed that each area-unit is filled *twice* over with a *single* electron giving thus 2, $2+8$, $2+8+8$, $2+8+8+18$, and so on, these being the numbers 2, 10, 18, 36, 54, etc., which are the total number of electrons present. This theory is so beautiful and comprehensive that it must be essentially true: at any rate it is likely to supplant the older theory that the electrons are in revolution round the nucleus like planets round a sun. Bohr has, however, recently suggested that 32 is succeeded by 18 and 8, not by 50.

The same theory, it may be noted, applies to the halogens fluorine, chlorine, bromine, and iodine. Fluoride *ion* F′ is $5\theta(10H^{+}10\theta\ 9H^{+})5\theta$ which is an "inert" structure like that of sodium ion and that of neon ($=5\theta(10H^{+}10\theta\ 10H^{+})5\theta$. So the chloride ion is $9\theta(18H^{+}18\theta\ 17H^{+})9\theta$ when its atomic weight is 35. When the atomic weight is 37* the constitution is $9\theta(20^{+}20\theta\ 17H^{+})9\theta$. Similarly argon of the atomic weight 40 (i.e., out of order in the Periodic table) is $9\theta(22H^{+}22\theta\ 18H^{+})9\theta$. Bromine ion† is $18\theta(45H^{+}45\theta\ 35H^{+})18\theta$, krypton being $18\theta(47H^{+}47\theta\ 36H^{+})18\theta$. Iodine ion is $27\theta(74H^{+}74\theta\ 53H^{+})27\theta$, xenon being $27\theta(76H^{+}76\theta\ 54H^{+})27\theta$.

The theory is, however, rather unsatisfactory for carbon and all the elements below it. Carbon would be $\theta(6H^{+}6\theta\ 6H^{+})\theta$ with a residual valency of plus 4, but, as I say later on, it is likely that the nucleus itself is arranged like a tetrahedron (as the valencies are) whereas the above is unsymmetrical. Similarly helium gas would be $\theta(2H^{+}2\theta\ 2H^{+})\theta$, which is very unsatisfactory from its lack of symmetry. Helium gas has in reality a round molecule, as shown by its Cp/Cv ratio. (See Fig. 5.)

Again if Rydberg's formula be examined, surprise will be felt that it does not read $N=2\ (1^2+1^2+2^2+2^2+3^2+3^2+4^2$, etc.) in which case it would be perfectly symmetrical. Assuming then this form of the equation, the successive sums are 2, 4, 12, 20, 38, 56, 88, these being therefore the number of electrons. Helium would be *second* in this series and have a shell of 4 electrons instead of 2. As it is neutral, one would have to assume a nucleus of $4H^{+}$, with the shell of 4 electrons far out and in tetrahedral order. The nuclear charge, the number of external electrons, and the atomic number would all be the same, *viz.*, 4, if two elements exist between hydrogen and helium. This very neat and satisfactory proposition is, however, knocked on the head by the existence of the α-particle of radioactivity which has mass 4 and two positive charges. It changes into helium on striking any kind of matter

* See Aston, *Phil. Mag.* 1920, 611 and my prediction, "Modern Alchemy and Transmutation" J.S.A. Association Anal. Chemists, 18/9/17.

† Since this was written, bromine has been found to be 79 plus 81, not 80.

and is therefore regarded as helium nucleus. The only explanation of these contradictions that suggests itself to me is that of rearrangement. Helium nucleus with atomic number 2 is unsymmetrical (see Fig. 6) viz. $(2H^{+}2\theta\ 2H^{+})$, but when two electrons are taken on to give helium gas, the arrangement $\theta(2H^{+}2\theta\ 2H^{+})\theta$, changes into

$$\begin{array}{ccccc} & & \theta & & \\ & H^+ & & H^+ & \\ \theta & & & & \theta \\ & H^+ & & H^+ & \\ & & \theta & & \end{array}$$

Although there *is* experimental evidence regarding the nucleus in this case there is none in the case of any of the others. Carbon nucleus as $(12H^{+} + 6\theta)$ is merely a deduction from helium nucleus $(4H^{+} + 2\theta)$. If the atomic number of carbon is 8, not 6, the nucleus is $(12H^{+} + 4\theta)$ which can be constructed as a tetrahedral model, whereas $(12H^{+} + 6\theta)$ cannot. (See Fig. 7.) In addition the *four* electrons which would then be required to make a kernel out of a nucleus could also be arranged tetrahedrally, and finally the remaining four valency electrons would form an outer tetrahedron.

At this stage a brief *résumé* of the experimental evidence for the present-day view of the atom is necessary. The essential conception, as I have mentioned in the introduction, is that the atom is hollow, consisting of a sphere, or concentric spheres, of electrons with an outer diameter of about 10^{-8} cm, and an exceedingly small nucleus (about $\frac{1}{1000}$ of the diameter of the electron sphere), which, however, contains nearly all the weight of the atom, and in the case of a heavy element a very high positive electric charge. Just outside this nucleus there is an immensely powerful electric field due to the action of the positive nucleus and the sphere or spheres of electrons. This conception, which is due to Sir E. Rutherford, arose in order to explain the fact that the α-particles of radium, which are about 7,000 times as massive as electrons and which are positively charged and travel with a speed of about 50,000 miles a second, when passed through thin metallic sheets, are deviated through large angles just as the tiny electrons can be deviated by *moderate* electric fields. The highly-deviated particles are those which have not only penetrated the electron-sphere of the atom but have passed uncommonly near to the nucleus and have thus been thrown into a hyperbolic orbit despite their immense velocity. It is conceived also that those which actually aim at the nucleus of a larger atom are turned back in their path.

This conception holds in its simplest form for the first 20 (or so) elements which have only *one* sphere of electrons. For the higher elements it is necessary to assume two or three concentric spheres (or octets, see page 51) of electrons and a bigger and more highly charged nucleus, until at the top of the series the nucleus becomes unstable owing to its excessive charge and disintegrates automatically, giving rise to radioactivity. Since atoms are electrically neutral, the total number of external electrons in the spheres must be equal to the posi-

tive charge of the nucleus. The number of external electrons can be estimated experimentally from the scattering of X-rays because each electron is, comparatively speaking, far apart from its neighbours and thus acts as an independent agent. Barkla thus found by trying different elements that the number of electrons is always a little less than half the atomic weight of the scattering element. Again, calculation from the deviation of α-particles (mentioned just above) when they are passed through different metals, leads to a result for the positive charge of the nucleus amounting to the electrical unit multiplied by about half the atomic weight of the element used as a screen. These two experimental lines thus converge to the same result. Again in 1913 Moseley*, a young genius who was killed in the war, applied the principle of the X-ray spectrum, which has proved very fruitful in the case of salt crystals, to the lower elements, and discovered the remarkable law, $N = K \lambda^{\frac{1}{2}}$, in which λ is the wavelength of the chief X-ray line given by an element, and N is a number which is a natural integer, going up by 1 as the element investigated goes up the Periodic Table. N is in fact an "atomic number" which depends only on the place of the element in the Periodic Table. Curiously enough, when the results are plotted, the bottom of the series is found at helium not at hydrogen, so that N is not the Chemist's atomic number but one less. It is seen at once that N is also about half the atomic weight, so that *three lines of evidence converge* to prove that the nuclear positive charge (and in consequence the number of external electrons) are determined in the case of each element by its position in the Periodic System and are numerically identical with the "atomic number" as defined above.

The Periodic Table is thus explained away (except for its arrangement in 8 or 10 columns) since for example sodium metal has 11 plus charges in its nucleus and 11 electrons outside, and the next element (magnesium) has 12 of each, thus putting up its "valency" by one. Valency is of course, as mentioned on page 47, the criterion of chemical properties, which have nothing to do directly with the nucleus of the atoms, but are solely conditioned by the external electrons, and, to speak more particularly, are almost solely conditioned by the number and arrangement of the few outermost electrons which are left over from fitting the atom with a spherical shell. As already indicated on page 51, sodium is monovalent and aluminium trivalent because the completed shell† of *all* the elements N, O, F, Ne, Na, Mg, Al contains 10 electrons, leaving respectively 1 and 3 over for valency electrons. Similarly the negative valencies 1, 2, and 3 of fluorine, oxygen and nitrogen are due to their possessing respectively 9, 8, and 7 external electrons, whereas 10 are required to make an inactive shell of the same shape as that of neon. The latter is inactive because it has 10 external electrons exactly (being the 10th element in the Periodic Table) and therefore none over or under the number

* *Phil. Mag.*, 1913, 1024 and 1914, 703.

† The "completed shell" is, it may be repeated, the ionised form of the element.

required for a complete shell. The analogous cases amongst the higher elements will be discussed later on.

Disintegration experiments. It has been stated above that the particle which hits a heavy nucleus full-on is reflected back. This is not the case, however, when the nucleus in question is small. In that case the nucleus is carried on in front of the impingin· α-particle and the atom is thus disintegrated. The simplest case is that of hydrogen gas or of organic compounds containing much hydrogen, e.g,, wax; when these are bombarded with α-particles, hydrogen nuclei (i.e., hydrions) are expelled. They are recognised by travelling far further than the α- particles themselves can travel against a resistance. Their weight is 1 with a positive charge 1: their initial velocity is $\sqrt[3]{4}$ times that of the α-particle. Their diameter is said to be about 3×10^{-13} cm, that of the α-particle being about 5×10^{-13} cm. Now Rutherford 2 or 3 years years ago made the astonishing discovery that the same kind of particle could be obtained by bombarding nitrogen gas or certain solid compounds of nitrogen with α-particles. We conclude that they came from the nucleus of the nitrogen atom, which thus contains hydrogen nuclei, in a sufficiently separate form for them to be capable of receiving a direct impact from an α particle. Check experiments with CO_2 and O_2 as gases, and with silica and graphite as solids gave negative results. A mixture of $7\frac{1}{2}\%$ hydrogen gas with $92\frac{1}{2}\%$ CO_2 or oxygen behaved towards the α-particle exactly like nitrogen gas, giving the same number and intensity of "hydrogen particles." By means of magnetic deviation they were shown to have mass 1 and charge 1. The infrequency of the direct impact required to generate "hydrogen particles" is shown by Rutherford's estimate that only one in 300,000 of the α-particles hits in the required way. Of the other elements tried, boron, fluorine, phosphorus, sodium, and aluminium were also found to contain removable hydrogen, but Li, Be, C, O, Mg, Si, S, gave negative results. It is probable, however, that all the elements are made of hydrogen but contain it in the form of local condensations of hydrion and electrons which are themselves so stable that they do not break up on impact with an α-particle; there are two of these, *viz.*, H_3^{++} and H_4^{++}.

Rutherford's discovery of the disintegration of nitrogen was so important that he had to publish it at once without waiting to ascertain what the rest of the nitrogen atom was made of. He therefore announced that the atomic weight 14 belonging to nitrogen probably consisted of two hydrogen atoms combined with three helium atoms. On continuing his experiments, however, he soon found that the hydrogen particles were accompanied by another set of characteristic particles 5 to 10 times as many in number which differed from any previously known. From the range and magnetic deviation they were shown to possess mass 3 and charge 2 and thus to be similar to the α-particle with only $\frac{3}{4}$ of the latter's mass. Nitrogen of mass 14 was thus inferred to consist of 4 particles of mass 3 instead of 3 particles of mass 4 in addition

to the two hydrogen nuclei. Rutherford gives the following diagram:—

$$\begin{matrix} & 3^{++} & & 3^{++} & \\ \theta & H^{+} & \theta & H^{+} & \theta \\ & 3^{++} & & 3^{++} & \end{matrix}$$

for the nitrogen nucleus, but expressly states that the arrangement is arbitrary. Since carbon and oxygen give no hydrogen particles, Rutherford infers that carbon nucleus is

$$\begin{matrix} 3^{++} & 3^{++} \\ \theta & \theta \\ 3^{++} & 3^{++} \end{matrix} \quad \text{and oxygen nucleus is} \quad \begin{matrix} 3^{++} & & 3^{++} \\ \theta & He^{++} & \theta \\ 3^{++} & & 3^{++} \end{matrix}$$

the three elements N, C, and O thus being depicted as having in their nuclei an excess of plus charges which is 7, 6, and 8 respectively, agreeing with their atomic numbers. As explained above, the 3^{++} and He^{++} particles are not capable of being disintegrated.

To complete this series it may be mentioned that boron nucleus appears undoubtedly to be nitrogen minus 3^{++}, viz.,

$$\begin{matrix} & 3^{++} & \theta & 3^{++} & \\ \theta & H^{+} & & H^{+} & \theta \\ & & 3^{++} & & \end{matrix}$$

(See Fig. 10.)

I am immensely interested in these conclusions, for some of you may remember that many years ago, long before the conception of a nucleus for the atoms arose, I predicted* that nitrogen would be found to be CX in which X is an unknown element of atomic weight 2. This prediction was made on purely chemical grounds such as the relation of pyridine to benzene.

I also predicted that carbon would be found to consist of a tetrahedral arrangement of 4 sub-atoms of weight 3, and that oxygen is CX_2. This paper gave rise to an active discussion, hingeing mainly on the isomerisms which would be postulated by such a theory. Thus nitrogen gas and CO gas would be isomeric both being C_2X_2. The extraordinary physical resemblance of these two gases has been recently dealt with by Langmuir.

On Rutherford's modification of my theory the two gases are no longer isomeric but metameric, because the nuclei differ in weight, but in all other particulars of their constitution they are essentially the same, as will be seen later on.

There appears to be some chance that the element of atomic weight 3 from nitrogen, which I ventured to call *zoicon*, will be found in minerals. After it has lost its positive charges by hitting electrons the 3^{++} particle must become an inert gas closely resembling helium and possessing a spectrum similar to that of helium with a displacement. This is on the assumption that the inert gas will have *two external* electrons just as helium gas has. If, however, it has one electron inside and another outside, this deduction would not hold and it would become possible that the new gas is the nebulium of the nebulae, with the constitution $(\theta 3^{++})\theta$ and a spectrum more like that of hydrogen than that of helium. The 3^{++} particle is itself probably complex, *viz.*,

* "Some suggestions for a new atomic theory," *Journ. Chem. Metall. & Mining Soc., S.A.* April, 1909, page 335, also September, 1909, page 98.

H^+ H^+, (see Fig. 8), and the α-particle (helium nucleus)
θ 4^{++}, is H^+ H^+
H^+ θ θ
(See Fig. 6.) H^+ H^+

As regards the monovalent element $X=2$ which I predicted in 1909, Rutherford's discovery seems to indicate that it only exists in nuclei and that it is constituted $H^+ \theta H^+$, so that it yields H^+ on impact.* This means that the α-particle is composed of two of these X elements, and the 3^{++} particle is composed of one X and one hydrion.† The stability possessed by 3^{++} and 4^{++} is in my opinion due to the symmetrical (*viz.*, triangular and tetrahedral) arrangement developed in them when they are made up from $H^+ + X$ and $X + X$. In this way Rutherford's conception of oxygen nucleus as CHe becomes the same as my conception of it as CX_2.

In connection with this subatom X^+, I am very pleased also to find that Prof. Harkins, another pioneer of atomic structure, has now come to the conclusion that it is "the primary group in atom building‡, and agrees with me that the α-particle is X_2^+. Harkins by the way writes X^+ as p_2e, but his p is the same as my notation H^+ and his e is the electron, so that p_2e becomes $(H^+ \theta H^+)$, which is my conception of X^+. (See Fig. 9.) It is unfortunate that different scientific writers should use different terms for the same entity, and I suggest that H^+ should always be called hydrion, not hydrogen-nucleus or proton or H-particle. X^+ should also have a name, since "isotopic hydrogen" is unsatisfactory; possibly the name *aërion* would do. Harkins uses the very suitable name *neutron* for the nuclear combination $(H^+ \theta)$, which is required according to Rutherford and himself to account for the existence of the elements whose atomic weight is greater than twice their atomic number (see rubidium, p. 51). Thus chlorine nucleus of at. wt. 35 is $X_{17} + N$, in which N stands for one neutron. and 17 is the atomic number. Aston's chlorine-nucleus of at. wt. 37 is then $X_{17}+N_3$.

Assuming then the sub-atom X^+ $(=H^+ \theta H^+)$, an extraordinary connection between the nuclei of inert gases and the saturated hydrocarbons can be demonstrated. CX_4 adds up to 20 and corresponds to neon. C_2X_6 adds up to 36 and corresponds to the lower isotope of argon, with the constitution CX_3CX_3. Again $C(CX_3)_4 = C_5X_{12}$ (cf. tertiary butane) adds up to 84 and agrees with the nucleus of krypton and has also the required round shape. Similarly C_8X_{18} adds to 132 which agrees with xenon, and $C_{14}X_{30}$ adds to 228 which may be the highest isotope of niton. Adding three α-particles to this niton gives $U=240$. The highest possible element would then be $C_{17}X_{36} = 276 = C\,[C(CX_3)_3]_4$. Some extra binding-electrons are required to give the correct atomic numbers. This kind of formulation puts all the X's to the outside of the nucleus, and thus explains radioactivity, as the X's get

* He says (Bakerian Lecture) "It seems very likely that the electron can also bind two nuclei . . . . . this entails the possible existence of an atom of mass 2 carrying one charge, an isotope of hydrogen," i.e. monovalent.

† I predicted this also in 1909.

‡ Nature 1921, p. 203.

crowded together on the surface of the nuclei of the higher elements and are thrown off in pairs, X_2 being the *a*-particle. It is thus the accumulation of X rather than that of positive charge which causes radioactivity.

To repeat, the contention I wish to make is that the physicists, as far as I understand them, have placed too much emphasis on the fact that chemical properties depend on the valency electrons, and have not considered the possibility that the arrangement of the valency electrons themselves probably depends on the prominence of certain points in the nucleus, e.g., that a tetrahedral arrangement of valencies in CH_4 and NH_4^+ connotes a *tetrahedral nucleus* for C and N.

The second point concerns Moseley's law for the K-lines in X-ray spectra. The expression $1/\lambda = K(N-1)^2$ becomes $1/\lambda = K.2^2$ for lithium. If we make the simple assumption that H^+ is a nucleus and the only free nucleus known (omitting the products of radioactivity) hydrogen becomes an entity *sui generis*, and the first real ordinary atom is helium. Moseley's law then becomes $1/\lambda = K_1\ (N+1)^2$, in which N is zero for helium and is not the atomic number but the number of *valency* electrons in the smaller elements. For higher elements N is the number of electrons outside the kernel.

For the L series of lines in the higher elements it is possible that the law is that $1/\lambda$ varies as the square of the atomic *weight* (not number) counting neon as zero number (i.e., subtracting 20), *viz.*, $1/\lambda = C(A-20)^2$ instead of $1/\lambda = \frac{5}{27}K\ (N-7.4)^2$ as given by Moseley.

Some account of Gilbert Lewis's octet theory (*J. Amer. Chem. Soc.*, 1916, 768) which is almost certainly true for the elements higher than oxygen, may now be given. *Fluoride ion, neon* and *sodium ion* all have the same octet of electrons; but in *fluorine atom* one is missing, leaving a "hole." In *sodium metal* one is in excess. In sodium fluoride the extra electron of sodium metal fills the hole in the fluorine atom: both then become ions even in the crystal state, and both have complete octets, thus:—

$$\underbrace{[4\theta\ [Na^{+9}]\ 4\theta]\ \theta}_{\text{Metal: kernel and electron}} + 4\theta\ [F^{+7}]\ 3\theta = \underbrace{\underbrace{[4\theta\ [Na^{+9}]\ 4\theta]}_{\text{Sodium ion}}\ \underbrace{[4\theta\ [F^{+7}]\ 4\theta]}_{\text{Fluoride ion}}}_{\text{Sodium Fluoride crystal.}}$$

Note.—The expression Na^{+9} is really Na^{+11-2}, the atom having 2 inner electrons to make a kernel out of a nucleus (see page 51). The fundamental conception might appear (reading Lewis strictly) to be that the same electron belongs to two atoms when a compound is formed, but undoubtedly in the *ionisable* compounds the metal electron is transferred and the residue, which is the metal ion, is quite independent not only in solutions but in crystals, the atoms in which are simply held together because one ion is positive as a whole and the other negative as a whole. In the case of such a substance as methyl chloride, the hydrogens are held in the nonionisable manner (see p. 50), but the chlorine is partly present as chloride ion, since powerful reagents like silver nitrate can remove

it. In the case of such a compound as chlorobenzene, however, the chlorine is completely un-ionised and it is to be assumed that the chlorine is much closer to the rest of the molecule and has an electron in common with the carbon to which it is attached. The chlorine "shell" is a cube* and the carbon "shell" a tetrahedron, and the corner or point of junction is the same electron. Generally speaking, the conception is that when 8 electrons get established round a nucleus the result is a saturated body which is incapable of further chemical action: it is only rendered active again by electrolysis or analogous process.

There are great difficulties in accepting Gilbert Lewis's octet theory of valence for the lower elements, although it is probably true for the higher elements. The new suggestion I wish to bring forward is, as already said, that the arrangement or structure of the nucleus governs the structure of the valency electrons in the smaller atoms. The nucleus, although its actual weight has nothing to do with chemical properties, thus indirectly influences the direction in space of the valency electrons and consequently affects the chemical properties of the atom by its *arrangement*, not by its size. Thus to make my position quite clear even at the risk of repetition, the arrangement of the carbon nucleus has the shape of a regular tetrahedron, that of the nitrogen-nucleus, the shape of a tetrahedron or pyramid with one point farther from the centre than the other three, and that of oxygen the shape of an irregular tetrahedron with two points nearer and two points farther from the centre. Each valency electron in the case of carbon has its average position in line with a projection of the nucleus, giving a regular tetrahedral result.

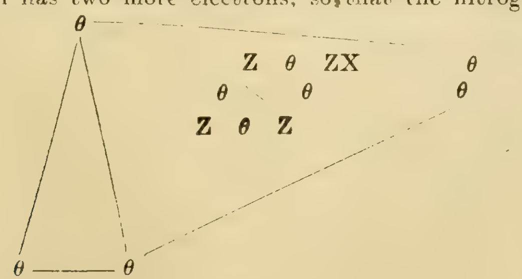
In nitrogen, 3 of the valency-electrons are arranged as in carbon, namely in line (from the centre of the nucleus) with the 3 nuclear points which are nearer the centre: whilst the other two form a saturated pair lying opposite the fourth point of the nucleus where the group X^+ is attached to the nucleus. Putting Z^{++} for

$H^+ \quad H^+$

$\quad \theta$ and X^+ for $H^+ \ \theta \ H^+$, the carbon nucleus becomes

$\quad H^+$

$(Z_4^{++} + 2\theta)$ (see Fig. 7), the carbon kernel becomes $(Z_4^{++} + 2\theta)2\theta$, and the carbon atom becomes $\lceil(Z_4^{++} + 2\theta)\ 2\theta + 4\theta\rceil$ the whole arrangement being tetrahedral. The nitrogen nucleus is $(Z_3^{++} + 2\theta + X^+)$ or $(Z_3^{++} + 2\theta + Z^{++}X^+)$ the nitrogen kernel has two more electrons, so that the nitrogen atom is:



* Or Sir J. J. Thomson's skew-cube ("skube").

Nitrogen gas N_2 is thus of the same structure as acetylene, i.e., $CX \vdots CX$ as compared with $CH \vdots CH$; and the "metameric" gas carbon monoxide has the same external structure as nitrogen and acetylene, i.e., each atom having 5 electrons round it, of which two form a neutral pair. The ordinary notation of this formula would be $C \vdots O$, which on my theory (and referring to the *nuclei only*) is $C \vdots CX_2$. This, of course, involves the actual transfer of an electron from the oxygen atom to the control of the carbon atom. This theory explains well why the two gases are almost identical physically, while there are still two "shells" in agreement with the Cp/Cv ratio, which is violated by the Lewis-Langmuir theory of two nuclei inside one shell of electrons.

The existence of nitric oxide in the form NO instead of N_2O_2 is a stumbling block for all the existing theories of chemical affinity. The problem is analogous to the existence of free atoms in sodium vapour and hot iodine vapour. Probably the best provisional explanation on my theory is to formulate it like carbon monoxide, thus employing 10 of its 11 electrons, leaving the extra electron in an outside position similar to that of sodium metal. (See Fig. 11.)

The nature of ammonia gas and ammonium ion may next be discussed. The former may be written, following Lewis, as in Fig. 12, which having altogether 17 plus and 17 minus charges, is neutral. It has, however, at one end a free pair of electrons and therefore has an affinity for hydrion, which can add on at that point, giving $\left[N^{14+}_{9\theta}\right] \left({}^{\theta}_{\theta}H^{+}\right)_4$, which is ammonium ion, a substance which has the same saturated tetrahedral configuration as methane, but has a total of 18 plus and 17 minus charges and is therefore positively monovalent. Ammonium chloride contains this ion and the chloride-ion existing side by side at some distance from each other just as in sodium fluoride previously discussed. When the latter is electrolysed the fluoride ion loses an electron, whilst the sodium ion gains an electron and thus becomes metal. In the case of ammonium also no doubt the metallic phase $\left(NH_4{}^{18+}_{17\theta}\right)\theta$ must come into existence for a moment,, but since the external electron must be near a group $\begin{smallmatrix}\theta\\\theta\end{smallmatrix}$ H^+, the result is dissociation into $\begin{smallmatrix}\theta\\\theta\end{smallmatrix}$ and $(H^+ \theta)$, i.e., into NH_3 gas and nascent hydrogen.

The nature of water and steam on this theory is worth notice. Following the analogy of ammonia as related to methane, water (vapour) becomes as in Fig. 13, which altogether has 18 plus and 18 minus charges, so is electrically neutral. It has two pairs of electrons left free and thus can combine either once or twice with hydrion giving $(OH_3)^+$ and $(OH_4)^{++}$. Liquid water and ice are the hydrates of these complex ions, $(OH_3)^+$ $(OH)'$ being H_4O_2 and H_6O_3 being $OH_4)^{++}$ $(OH)_2''$. This theory accounts for the very low dissociation of water since owing to the combination, *viz.*, $\left[OH_3{}^{19+}_{18\theta}\right] \left[OH^{17+}_{18\theta}\right]$

there is scarcely any free hydrion, the constitution being not unlike that of C_2H_6. No doubt aqueous hydrochloric acid when strong contains (OH_3) Cl and (OH_4) Cl_2. On this theory the angle between the two valencies of oxygen is not very different from that in the case of carbon. Hence H – O – H is misleading, and H_2O should be printed $O\genfrac{}{}{0pt}{}{\diagup H}{\diagdown H}$

Another spatial consideration is that NH_4 ion, owing to the fact that the tetrahedron of hydrogen attached to *valency* electrons is far out from the N atom, has an abnormally large volume (as compared with sodium). This agrees with the fact that ammonium and the large atom rubidium (weight 85) are mutually replaceable in crystals.

The conceptions for KNO_3 and $KClO_4$ are specially interesting. The NO_3 ion has 23 plus charges (3 sixes from oxygen and one 5 from nitrogen) and 24 binding electrons (3 octets): its valency is therefore –1, the same as that of fluoride ion (valency +7–8). Similarly the ClO_4 ion has 7 + (4 × 6) = 31 plus charges, and 32 binding electrons (4 octets), giving a total valency of –1 also: similarly SO_4 has 30 plus and 32 minus, giving a valency of –2: PO_4 similarly is 29 plus and 32 minus = –3.

This paper would not be complete without some account of the nature of the spectrum lines of the elements. In the first place it is known that these lines, like the valency of the element, have their origin in the outermost electron-shell of the atom. The spectrum of hydrogen which by theory arises from a single electron has been already reduced to a mathematical formula, *viz.*, $\frac{1}{\lambda} = 1097 \left[\frac{1}{2^2} - \frac{1}{N^2}\right]$ in which N is successively 3, 4, 5, 6, etc. This is a harmonic series beginning with λ 6563 (line C of the sun) and terminating by superposition at λ = 3650. Hydrogen has also an ultra-violet spectrum for which $1/\lambda = 1097 \left(1 - \frac{1}{N^2}\right)$ and N is 2, 3, 4, etc., successively. Similar but more complex, formulae, also depending on inverse squares of natural numbers, hold for the other elements.

N. Bohr has suggested that the cause is revolution of the electron in a constant slightly-elliptic orbit round the nucleus, with the possibility of it suddenly jumping from one orbit to another, thus giving what is called a *quantum* of radiation. The mathematics of this peculiar theory lead not only to the above formula for the frequency of the different kinds of light emitted, but also predict the fine structure of the spectrum lines when seen under high resolution. Nevertheless Sir J. J. Thomson declares that when there are several electrons no stable orbit is possible, so he suggests that the electrons vibrate in and out instead of round, that the nucleus repels when the electron goes near and attracts when it is far, thus giving a neutral position where there is no force. which neutral position is that of the electron in the unstimulated atom. This theory also leads to the octet (skew-cube) arrangement when the number of electrons is large. Now in crystals it is known

that there also resides a repulsive force preventing compression and varying as the inverse tenth-power of the distance, so we see that Crystallography also is being swallowed by Physics just as Chemistry has been, and this unification of the Sciences is all to the good.

In conclusion I have to apologise for being unable personally to represent some of the other Sciences comprised in Section B. I invite the attention, however, of the devotees of that non-experimental Science Geology to the possibility that some of their cherished replacement theories may have to go to the wall—in other words that what appears to be replacement may be transmutation. Thus carbon appearing in silica is very easily explained if silicon nucleus is CHe_4, as I suggested in 1909. So if zirconium-nucleus is C Ne_4, titanium Si Ne and niobium N Ne_4 their genesis becomes easily understood. The pressures in the interior of the earth may be sufficient to overcome the repulsive force in the atoms (even though as already said it varies as $1/d^{10}$) and thus transmute them by simple squeezing. Such minerals as the trio $SrSO_4$, YPO_4 and $ZrSiO_4$ could be changed into one another quite easily on this theory, since the number of hydrions is the same in all of them. When I have come across an ordinary geological theory I have always felt like Cato, "Semper miror quod non rideat haruspex haruspicem quum viderit," so when Geologists meet and see one another here in this section I hope they will take the hint and wink discreetly.

Explanation of Plate 1.

Fig. 1. Hydrogen Atom or "Nascent Hydrogen."
Fig. 2. Hydrogen Gas.
Fig. 3. Lithium Ion.
Fig. 4. Beryllium Ion.
Fig. 5. Helium Gas.
Fig. 6. Helium Nucleus or Alpha Particle.
Fig. 7. Carbon Nucleus.
Fig. 8. Zoicon Nucleus, 3++.
Fig. 9. Aerion Nucleus 2+.
Fig. 10. Boron Nucleus.
Fig. 11. Nitric Oxide Molecule.
Fig. 12. Ammonia.
Fig. 13 Water Vapour.

Fig. 1.

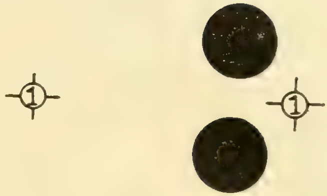


Fig. 2.

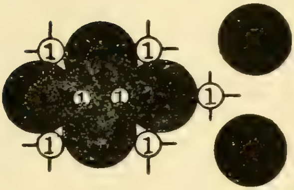


Fig. 3.

Fig. 4.

Fig. 6.

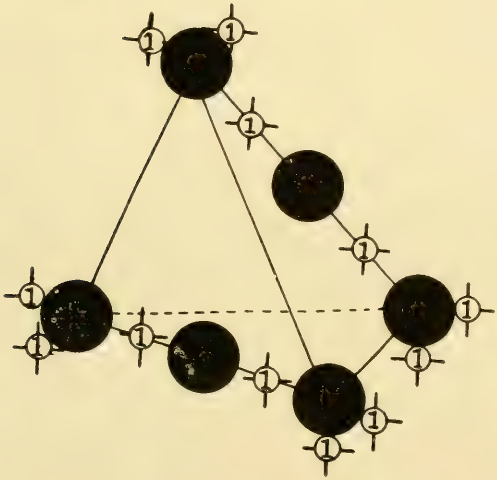


Fig. 7.

Fig. 8.

Fig. 9.

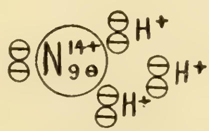


Fig. 12.

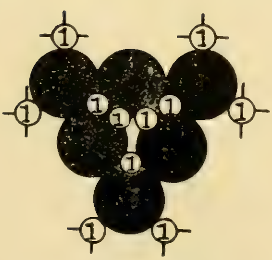


Fig. 10.

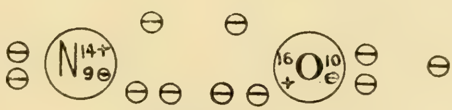


Fig. 11.

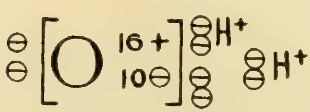


Fig. 13.

CONSTITUTION OF ATOMS AND MOLECULES.

SOME ASPECTS OF BOTANY IN SOUTH AFRICA AND PLANT ECOLOGY IN NATAL.

By J. W. Bews, M.A., D.Sc.,
Professor of Botany, Natal University College, Pietermaritzburg.

Presidential Address to Section C, delivered July 14, 1921.

Introduction.

Botanists, probably to a larger extent than workers in other branches of science, are the product of their environment. It has been noted more than once that the direction of many important advances in Botany has been determined by the conditions surrounding and influencing the men responsible for opening up the new pathways. At one time an extended exploration trip was considered the best possible training for a young botanist, and though with the increasing development of laboratory work this course has, during the last generation or two, not been so much followed, no one is likely to deny that it proved itself of immense value. It is difficult, for instance, to estimate what the world owes to the fact that Darwin made the voyage in the "Beagle." Church, in his recently published memoir, "Thalassiophyta," maintains that many of the leading ideas which dominated botanical teaching and research from Hofmeister to Bower would have been considerably modified, if the earlier continental writers, including Hofmeister himself, had lived near the sea and had known more about seaweeds, plants which are only now receiving the attention they deserve. Be that as it may, there can be no doubt that the progress of Botany is very distinctly determined by the material and problems with which the leading botanists at each period are brought into contact.

Many important advances have been made along different lines, and each one, for a time, has had a more or less dominating influence over those who perform the important and necessary work of clearing up the details. This is not to be regretted, and it is, in fact, a feature which Botany shares with all other sciences. After a rough trail has been broken the pathway has to be cleared. It is curious, however, how the breaking of new trails often arouses a considerable amount of opposition on the part of those who maintain that the only research work worth doing is that which helps to open up certain main lines of development. There may be more than one reason for this. Since the majority of professional botanists are engaged in teaching the subject, it is necessary for them to direct the attention of their students chiefly to those main lines of development and difficulties which are met with that must be tackled and, if possible, overcome. Research along these same lines follows as a matter of course. Much of it, unfortunately, consists in applying a rather complicated technique in a purely

mechanical way, and it tends to stifle rather than develop any originality. Instead of being influenced by his real botanical environment the botanist is influenced rather by the environment of his own botanical school.

On the other hand, the type of enthusiast is common, who is far too ready to turn aside into all sorts of side tracks. He is never likely to reach any destination, because he never proceeds far enough in a straight line in any direction. It is very necessary that he should be disciplined by being forced to follow in the footsteps of others along the main highroads of the science. Whatever line one follows the main thing is to try to see the way clear as far ahead as possible and to keep straight on.

The Development of Botany in South Africa.

The history of Botany is a valuable and interesting study, which assists us greatly in obtaining a proper outlook. Our knowledge of this aspect of our subject is naturally chiefly confined to the older-established countries, but it is interesting to observe how a science like Botany grows, when it is transplanted into a new country like South Africa. To begin with, the only indigenous Botany was that of the native races. They possess a rather wonderful knowledge of the plants which, rightly or more often wrongly, they believe to be useful. The Zulus have a botanical vocabulary of at least a thousand words. They are not artists and do not draw plants, they know next to nothing of plant morphology and physiology, but they do observe carefully in some directions. They are able to distinguish closely allied species or varieties, which are usually confused by the white settlers, and they know a great deal about plant habitats. A study of the botanical knowledge of primitive peoples, if undertaken by a competent botanist, would have a considerable interest from the standpoint of ethnology, sociology and kindred sciences, as well as from our own. One is constantly reminded of the herbalists when one considers the plant lore of the Zulus. Their facts are so thoroughly mixed up with their superstitious beliefs.

The earliest European botanists who visited South Africa were explorers and collectors, men of the type of Thunberg, Burchell, Ecklon, Zeyher, Drège, etc. They were limited by the stage of progress of the science at their time, but no one who has read their works can fail to be impressed by their energy, resourcefulness, and immense power of assimilating and classifying new facts and details. This applies also to later workers, who spent a greater or less portion of their lives here, such as Harvey, MacOwan, Bolus, and Medley Wood. In our enthusiasm for "main currents" of investigation and "leading principles" there would seem to be some danger of our losing that power of dealing with masses of details and facts, though one would imagine that the discovery of more and more scientific laws would assist us in doing so. At any rate, in South Africa even to-day it is precisely this type of ability which is very much required. The conditions are so wonderfully diversified and different from those of other countries and the flora

is so rich that the number of new facts and new problems appear overwhelming. It is easy to add to the sum total of our botanical knowledge in South Africa. Almost any pathway is bound to be a new one. What is really difficult is to get on the hill-tops and survey the South African botanical landscape as a whole.

With the rise of our University system and the development of our colleges and schools, botanical knowledge in South Africa ceased to be confined to a small handful of workers. The subject could not possibly develop gradually on South African lines. The great majority of the teachers from the University downwards had to be imported, and the subject was transplanted with them. It had grown up under a very different environment elsewhere. Just as European plants, when imported into South Africa, take some time to change their seasonal variations to suit our reversed seasons, so it has taken Botany many years to react properly to its new environment in South Africa. To begin with, syllabuses were drawn up exactly on the lines of those of overseas institutions. Till quite recently, for instance, *Pellia* was the chief type of Hepatic studied in elementary classes, though *Pellia* does not occur anywhere in South Africa. Large quantities of botanical material for classes in practical botany were purchased overseas and imported. Though this state of affairs is gradually becoming a thing of the past, even now we have no satisfactory South African textbook of Botany.

Nevertheless, considering the comparative shortness of the time since its introduction and the many difficulties that had to be overcome, on the whole South African botanical teaching has made good progress. Our aim in the future should be, while keeping in mind the importance of obtaining a sound general knowledge of the subject, to make Botany in South Africa more and more distinctly South African.

This applies not only to teaching but to research work as well. If we approach our work in the right spirit we may look forward with confidence to the future. "Out of Africa always something new" will, I feel sure, continue to be true as far as Botany is concerned.

Botany in Natal.

Each of the various botanical centres in South Africa has its own problems which are being tackled. Since we are meeting to-day in Durban I think it may be considered appropriate that I should deal with some of the work that has been and is being done in Natal. The history of Botany in Natal begins with J. F. Drège, who, in 1832, accompanied by Dr. Andrew Smith, made a collecting trip along the coastbelt as far as the Umgeni, north of Durban. He was followed in 1839 by Ferdinand Krauss, whose account of his trip was published in 1846. Shortly after Pietermaritzburg was founded, and the country rapidly opened up by white settlers. The blacks were practically confined to Zululand at this time, those of Natal having been wiped out by Chaka. Very soon the pioneer colonists turned their attention to the rich vegetation which sur-

rounded them. Among the earliest plant collectors were Dr. Gueinzius, Messrs. Vance, Williamson, Plant, and Armitage, followed by Sanderson, Sutherland, Hallack, Buchanan, Fannin, Gerrard, and McKen (the first Curator of the Durban Botanic Gardens). I have given further details regarding the history of Botany in Natal elsewhere,* but since we are meeting here in the town, where his chief lifework was accomplished, it is only fitting that I should again pay tribute to the long continued, splendid botanical labours of Dr. J. Medley Wood.

He arrived in Natal in 1852, and died at Durban in 1915, at the advanced age of 88. It was my privilege to know him only during the last five years of his life, but in spite of his age I knew him as an active worker, for he was keenly interested in his subject to the very last day of his life. His botanical work in Natal extended over sixty years. His early collecting was done while he lived at Inanda, where he was visited in 1876 by A. Rehmann. In 1882 he succeeded McKen as Curator of the Durban Botanic Gardens. His preliminary catalogue of indigenous Natal plants was published in 1894. It was soon largely added to by his continued activities, and in 1907 appeared in the form of a "Handbook to the Flora of Natal." Still later, a Revised List of the Flora of Natal with two subsequent appendices appeared. His "Natal Plants," in which altogether 600 species were illustrated, did much to popularise botany in Natal. By building up the Durban Herbarium and by exchanging plants with other herbaria in various parts of the world, Wood made the flora of Natal known far outside its own boundaries. Many new species were described by himself and a still greater number were sent by him to be described by specialists at Kew and elsewhere. His long-continued, patient work has cleared many difficulties from our road, and he has thoroughly earned the lasting gratitude of all of us who have to follow him.

I must pass over the work of many who were associated with Medley Wood as well as of others. Fourcade investigated and reported on the forests of Natal in 1889. Justus Thode contributed a considerable amount to our knowledge of field botany and ecology. Dr. T. R. Sim has made the trees and shrubs, the ferns, and the mosses and hepatics his special subjects of study, but he has collected widely other plants as well. He has lately very generously handed over his herbarium of flowering plants to the Botany Department of the Natal University College, and he continues to assist us in adding to it.

During his tenure of the office of Conservator of Forests for Natal Mr. J. S. Henkel did much to further our knowledge of the plant ecology of Natal, and he demonstrated widely to farmers and tree planters that forestry is really applied ecology. The group of the fungi have been studied not only by Medley Wood, but by Dr. Pole-Evans and his staff, especially by Dr. Ethel Doidge, who

---

* Bews, J. W. "An Introduction to the Flora of Natal and Zululand." Pietermaritzburg. 1921.

is one of our most distinguished Natalians, and by Dr. van der Bijl, who is stationed here in Durban.

I have sent a fairly representative collection of freshwater Algae to Miss Stephens and Dr. Fritsch, and a paper dealing with them will, I understand, be published soon. The whole field of Botany is, therefore, being more or less completely covered from the systematic standpoint, and in all branches of the subject new facts and problems are being brought to light.

I now pass on to deal with the aspect of the subject to which I have given most of my own attention,

The Plant Ecology of Natal.

When we seek to describe in general terms the distribution of the vegetation over Natal, the first essential is to distinguish the various natural plant communities. The first attempts in this direction, which were made by various writers, consisted in picking out characteristic or interesting species which were found in different localities. The distinctions between the three main botanical areas, Coastbelt, Midlands, and Drakensberg, were drawn very early by Krauss (1846). Much later Thode entered into greater details on the same lines. Altitude, of course, determines climate in a general way, but altitude in itself is not enough. In the Midlands there are at least two very distinct climatic areas. For smaller areas soil conditions are sometimes important, but in Natal as in all great Continental regions the main subdivision must be based on climate.

As the analysis of the plant communities is proceeded with it is soon obvious that these are not to be considered of the same rank. Some, like various types of forest, are relatively stable, and except where they are destroyed by man remain more or less unchanged so long as the climate does not change. Other plant communities have a relatively short life in any locality. They are unstable, and represent what are regarded as stages in the development of the more stable types which gradually replace them. When we study the development of the vegetation in any area in this way we study what is known as the "Plant Succession." The most obvious method of doing so is by means of "Quadrats" or "Line" or "Belt Transects." Definite sample areas are carefully marked out, the plants on them counted and mapped, and the changes from time to time noted. Different quadrats are compared and the conditions are varied. The method is a true experimental one, but the difficulties in carrying it out successfully are great. The analysis of the habitat factors even with the assistance of instruments is difficult. One cannot be quite sure that two distinct quadrats, which are to be treated differently, are alike in all respects (especially with regard to soil conditions) to begin with, or whether each agrees with "control" quadrats. Nevertheless the results to be obtained by this method are very valuable, though for slow-growing types, a long period must elapse before any results are obtained.

Another method of analysing the plant succession is by means of observation and deduction—the method of the geologists. It

consists in interpreting Nature's own experiments. It has certain very definite advantages. While quadrat experiments carried out in one locality may not apply to another locality, observation by Nature's experiments can be made over very wide areas.

We observe, for instance, that certain grasses colonise bare areas such as old roads (species of *Aristida*, *Eragrostis*, etc.). Tufts of these pioneers are found elsewhere being smothered and killed by the denser growth of species (e.g., *Themeda*) which do not as a rule themselves act as pioneers. The latter are in turn themselves killed out by still taller species (*Andropogon*). Three stages of the succession are at once displayed, and it is unnecessary to await the course of events in certain definitely mapped quadrats, which, to give the same information with equal certainty, would require to be very numerous and to cover a very wide area.

A walk along the margin of a forest gives just as definite information regarding its history. If the marginal trees are all branched from the base outwards towards the light these trees cannot have grown up in the centre of dense shady forest. The forest in this case is not of the so-called retrogressive type. Its margins are not being eaten into by grass-fires. Further we often find that species characteristic of the scrub zone, which usually surrounds our forest-species—which are light demanders and quite intolerant of shade—may be found just inside the forest margin in a dead or dying condition. They have been overtaken by the forest trees. It is quite obvious that they could not have grown up in the shade from the beginning. Two stages in the succession are here clearly demonstrated, the scrub stage and the forest stage. But these stages may be connected with the grassland stages already analysed for the tall (*Andropogon*) species of grasses are in the same way seen to be killed out by scrub. We thus find displayed five stages of a complete unit succession or "sere."

By observing the natural regeneration of the tree species on the floor of a forest, by determining the relative ages to the commoner species, by searching for the causes of the death of certain species, further successional tendencies are brought to light. Not only can the past history of the forest be read, but its future development can be foreseen.

Cases of plants suppressing other plants are always to be looked for. A dead plant or a dying plant is a flag signal to the ecologist. Often the cause of death may not be suppression by other plants but an attack by insects or fungi. Insect attacks on the dominant species may change the whole course of the plant succession, and a stable type sometimes is changed without any change in climate, as in the case of the falcate yellowwood forests of the Drakensberg. There are many other interesting points in regard to the biotic factors and their influence on the vegetation of Natal. Plant succession is influenced greatly by seed dispersal and the agents controlling it, a subject which I dealt with briefly in a paper read before this Association at Stellenbosch.* The influence of Termites

* Bews, J. W. "The Plant Succession in the Thornveld." *S.A. Journ. of Science*. 1917.

is very great, both on soil and on the vegetation directly. Their tunnelling operations serve to loosen the soil, and they destroy dead wood everywhere as well as sometimes the living plants.

Their mounds are often the starting point of a clump of trees in the various kinds of Tree Veld. Earthworms and true ants in Natal as elsewhere are important because of their effects on the soil. Locusts and various caterpillars destroy vegetation and usually have a selective effect. Among the mammals there are many which dig for and eat bulbs and tubers. The bush-pig (*Potamochoerus*) is as efficient almost as an ordinary plough and helps very much in the extension of forest by providing a good germinating ground for the seeds of the forest species. The aard-vark or antbear (*Orycteropus*), which feeds on termites, forms large burrows in the veld. In disused burrows, characteristic species, shade loving at least in their early stages, are found, which cannot invade the undisturbed grassveld. Ferns, such as *Nephrodium athamanticum* and the tree fern *Cyathea dregei*, are examples.

The relations of the insect fauna and various birds to the vegetation in connection with flower pollination is a subject which has been very little studied in Natal. This applies also to the micro-flora and fauna of the soil. There is reason to suspect that a great deal of nitrogen fixation in the soil takes place, but we know nothing about it with certainty.

In a few rare cases a curious biotic result is seen in connection with the plant succession. A whole plant community, if left alone, seems to commit suicide. The dominant species grows so dense as to prevent any regeneration either from its own or other seedlings, and the individuals stifle one another and become unhealthy. They die in numbers so that the whole community is readily destroyed by fire. In the case of grassland the dominant species (*Themeda*) occasionally grows so dense as to prevent regeneration, and, if left unburnt and ungrazed, ultimately withers and dies and leaves the ground more or less bare. The phenomenon, however, it may be repeated, is a rare one.

Did time permit, much might be said regarding man as a biotic factor. His influence is usually destructive. He interferes with the plant succession by burning the grass or by overgrazing or by drainage and lowering the water-level, etc., so that stable climax types of vegetation are replaced by more primitive stages. We thus see how the various contradictory views regarding grass-burning can be reconciled, provided succession is studied over wide areas and generalisations from isolated data are avoided. If the succession is taking place in a forest climatic area and has advanced far enough to reach the beginnings of the scrub stage, the farmer, by burning the veld, can send back the succession to an earlier pure grassland stage. On the other hand, continuous burning of pure grassland itself tends to establish the most primitive stage of all, that is, wire grass or *Aristida* grassveld. Grass burning, therefore, may be necessary or it may not, and it is only by an understanding of the plant succession and the principles underlying it

that definite information can be given regarding the best procedure in each individual case. This forms one of the most important economic results of our study of ecology in Natal.

The analysis of the factors influencing the vegetation, climatic, edaphic and biotic, and the study of the plant succession has gradually led to the evolution of a more or less natural scheme of classifying the vegetation units or plant communities.

The Main Botanical Regions of Natal.

There is no doubt that Krauss, and later Thode, were right when they divided Natal, like ancient Gaul, into three parts, viz.: (1) Coastbelt, (2) Midlands, (3) Drakensberg or Mountain. These agree in certain important climatic features, especially in having a summer rainfall, so that Natal may be considered as one botanical region and these as sub-regions. The point is immaterial from our present standpoint. Altitude, however, is not the only possible basis for subdividing Natal. Owing to the rivers of Natal having cut down through the system of terrace plateaux between the Drakensberg and the sea, there is a system of deep valleys which contrast rather sharply with the ridges between them. The former are known as Low Veld, the latter as High Veld. The Low Veld is drier, has greater extremes of temperature, a richer soil which is more compact, and supports a generally more xerophytic vegetation than the High Veld. The Coastbelt is a distinctly subtropical region. Frosts are absent or very rare. The Low Veld on the Coastbelt is not so distinctly marked off from the High Veld as in the Midlands. By a recent downward movement of the continent to an extent of 150 feet or more the river mouths have been "drowned" and extensive alluvial flats have been formed. The whole of the actual coastline itself is covered by a mantle of blown sand to a distance of from half a mile to two or three miles from the shore. Close to the sea the sand has formed a line of dunes fixed by bush. The Drakensberg forms the lofty escarpment of the great inland plateau varying in altitude from 6,000 to 11,000 feet. It is a region of highly unstable topography. Though snow only falls occasionally and always melts early in spring, otherwise climate and soil conditions are of the usual extremely variable mountain type. The distribution of the plant communities will illustrate further the differences between the various botanical regions.

The Plant Communities in Natal.

Since plant succession is a universal phenomenon and fundamental in any natural scheme of classifying plant communities, the primitive or pioneer types will be dealt with first and the order of arrangement will, as far as possible, be that of the plant succession in each separate climatic area.

1.—*The Strand Vegetation.*

On the belt of shifting sand between the line of sand dune bush and the sea a number of interesting species, many of them widespread, represent the earliest stages of succession on sand (the

psammosere). There is room for much further intensive study and comparison of these species. Those that creep through the sand are replaced by those that creep over the sand, and these in turn by erect-growing shrubby species. *Hydrophylax carnosa*, *Scaevola thunbergii*, *Cyperus natalensis*, etc., creep through the sand and help to fix it. *Ipomaea biloba* grows partly through the sand and partly over it. *Mesembrianthemum edule* covers the surface over wide patches near the bush, and various grasses (*Stenotaphrum glabrum*, *Dactyloctenium aegyptiacum*, *Sporobolus pungens*) also form large colonies or associes. The erect-growing, shrubby or herbaceous species are very numerous, and form a transitional zone to the psammophilous scrub and bush of the fixed line of sand dunes.

2.—*Lagoon Vegetation.*

On the mud flats at the "drowned" river mouths, where the water is brackish, the most important pioneers are species of Salicornia (*S. herbacea*, *S. natalensis*) and *Chenolea diffusa*, but this succession requires further analysis also. The dominant species are the mangroves, which will be dealt with later.

3.—*Lake, Vlei, and Streambank Vegetation.*

This type extends from the coast to the Drakensberg, and, like other primitive stages of the succession, it varies only slightly with rising altitude. The succession is very easily followed since the various stages usually form distinct zones parallel to the water edge. There is a certain similarity in this hydrosere in all parts of the world. The stages in Natal are as follows:—

A. Submerged Aquatics. *Potamogeton spp.*, *Hydrostachys natalensis*, *Ceraphyllum demersum*, etc.

B. Floating Aquatics. Species of *Aponogeton*, *Nymphaea*, *Utricularia*, *Lemna*, *Pistia*, etc.

C. Reed Zone. *Phragmites* often mixed with *Typha*.

D. Semi-aquatics. A great variety of smaller herbaceous species, few of which assume complete dominance.

E. Cyperus—Mariscus Zone. Taller Cyperaceae.

F. Vlei grasses. Species of *Setaria*, *Pennisetum*, *Erianthus*, *Leersia hexandra*, and many others.

G. Other vlei consocies or associes of herbs, shrubs or trees which are transitional to sub-climax types.

4.—*Ruderal Vegetation.*

This represents the initial stages of secondary successions or subseres, and consists of the weeds, whether herbaceous or shrubby, which occur along roadsides and kafir pathways, in ditches and quarries, on rubbish heaps, waste land and cultivated fields, or where forest has been burnt out or cut down. The original vegetation has been destroyed and the soil disturbed, but as soon as it is left alone the processes of repair are initiated and a new succession commences which leads up to the original grassveld, scrub,

or forest. The majority of ruderals are excellent colonisers. They flower profusely and for a long period each year, and form large quantities of seed. Many are annuals, especially in cultivated land. These gradually give way to perennials. Many of the perennials have a creeping habit of growth. Few ruderals, however, can withstand shade, and the taller species kill out the low-growing. Many ruderals are introduced plants. The *Compositae*, *Solanaceae*, etc., are common all over, while the more tropical families, e.g., *Acanthaceae*, *Amarantaceae*, are more prominent on the Coastbelt.

5.—*Grassveld.*

The earlier stages of succession in this important type are similar all over Natal, while the later stages differ more in the different areas. Grassveld often is established by a succession from water and wet ground following after "vlei grasses" in the hydrosere already dealt with. The succession on dry soil and rocks (i.e., in the xerosere) is as follows:—

A. Lithophytes. Blue green Algae, Lichens, Mosses and petrophilous flowering plants, *Crassula* spp., *Cyperus rupestris*, etc.

B. Chomophytes or crevice plants. A large class, since practically any seed may germinate in rock crevices. Certain species, however, are distinctly characteristic of such situations, e.g., many Compositae (especially at higher altitudes) and bulbous Monocotyledons. Chomophytes may be (a) Exposed (often cushion forms or spreading), (b) Sheltered (including most of the bulbous species), (c) Shade (*Streptocarpus* spp., etc.), or (d) Hydrophilous (growing on dripping crags).

C. Primitive Grassveld. Species of *Aristida*, *Eragrostis*, *Sporobolus*, etc., which are bunch grasses with deep roots or *Cynodon dactylon* and other creeping forms which root at the nodes. All are light demanders and good colonisers.

D. The sub-climax and climax stages of grassveld. These gradually displace the pioneer species or follow after vlei grasses. Separate types in the different areas must now be distinguished.

1. Midland Grassveld. Of this there are two distinct subtypes, viz.: (a) High Veld, with *Themeda triandra*, var. *glauca* dominant and *Andropogon hirtus* and other species often subdominant. Invasion by species of *Acacia* and other pioneer trees leads to the establishment of Thorn Veld.

Mixed with the grasses are a great variety of associated plants which form (a) Vernal Aspect Societies, consisting mostly of either monocotyledonous or dicotyledonous geophytes with underground storage, the spread of which is favoured by grass-burning, or (b) Autumnal Aspect Societies, shrubby species which grow with the grasses, are kept in check by grass-burning and often represent transitional types to scrub and forest.

2. Coastbelt Grassveld. This is distinguished by the presence, though not by the dominance, of distinctly tropical species, e.g., *Pollinia villosa*, *Perotis latifolia*, *Pogonarthria falcata*, and

numerous species of *Panicum*, as well as by distinctive Vernal and Autumnal Aspect Societies. It is less stable than the Midland Grassveld.

3. Mountain Grassveld. The species composing this type are more temperate in their affinities, and they grow in hard tussocks with bare spaces in between. *Microchloa spp.*, *Harpechloa capensis*, *Festuca spp.*, *Poa spp.*, *Avenastrum spp.*, *Koeleria cristata*, *Anthoxanthum eckloni* are characteristic, but there is a considerable admixture of Midland species. Aspect societies are distinctive, both vernal and autumnal.

6.—*Tree Veld.* (Grassveld with scattered trees.)

The succession in this type is peculiar and characteristic. The pioneers are trees, not shrubs. Seeds of the pioneers are scattered by animals, chiefly birds, and each pioneer tree serves as a centre around which a clump of trees and shrubs becomes established. Tree veld of various kinds is very widespread in the continent as a whole. The following are the chief types of it in Natal:—

A. Thorn Veld or Acacia Veld. *Acacia Karroo*, *A. benthami*, and other species are the chief pioneers and remain dominant over most of it. *Gymnosporia buxifolia* and a great many other species are associated. This type fills most of the great river valleys of the Midlands with extensions to the drier parts of the Coastbelt, where *Dichrostachys nutans* becomes prominent together with tree Euphorbias, etc.

B. Midland (Highveld) Tree Veld. A mixed type which can be subdivided into several associations. It occurs above the Thornveld, and Acacia species are rare or absent. *Cussonia spicata*, *Combretum spp.*, *Erythrina tomentosa*, *Greyia sutherlandi*, *Maesa lanceolata*, *Dombeya spp.*, *Commiphora spp.*, are a few of the more prominent species. A good example of it has been analysed by Mr. R. D. Aitken.

C. Aloe Veld. *Aloe marlothii* and other species grow usually on rocky slopes, sometimes associated with Thorn Veld.

D. Hygrophilous Tree Veld. This is usually merely a stage in the forest succession. (See Hygrophilous scrub and forest later.)

E. Faurea Veld. *Faurea saligna* dominant. This occurs on certain sandy soils, e.g., near Pinetown, and again above Albert Falls. Also might be placed under the heading "scrub and forest."

F. Coastbelt Tree Veld—a mesophytic type. *Cussonia umbellifera*, *Strelitzia augusta*, *Vangueria infausta*, *Albizzia fastigiata*, *Sapium spp.*, *Drypetes spp.*, *Spirostachys africana*, etc.

G. Ilala Palm Veld. *Hyphaene crinita* is dominant. It occurs all along the coast behind the dunes on the drift sands. In Zululand it covers a great belt from 20 to 30 miles wide.

H. Bush Veld. This type (similar to that of the Transvaal) was discovered recently in N.E. Zululand by Aitken and Gale. *Terminalia sericea*, *Combretum spp.*, and various Aloes are conspicuous in it.

I. Protea Veld. Various species of Protea (e.g., *P. roupelliae*) are dominant. This type is extensively developed on the lower slopes of the Drakensberg.

7.—*Scrub and Forest.*

The various close woodland plant communities in Natal, though not all belonging to the same formation, may conveniently be grouped together. They are generally known as Bush in Natal —a somewhat vague term. The pioneers are shrubs which form marginal zones following after tall Andropogon grasses. The succession is commonly initiated along the streams where the seeds are carried by birds, etc., while the intervening ridges are colonised later. The scrub zone provides the necessary shade for the species which belong to subclimax and climax forest stages. These are shade loving, at least in their early seedling stages of growth. The following types of woodland may be distinguished, beginning with the Coastbelt:—

A. Mangrove Association. This occurs on the mudflats at the river estuaries where the water is salt or brackish. The Natal mangroves are *Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnothiza.*

B. Psammophilous Bush. This covers the coast sand dunes. Earlier scrub stages consist of such species as *Osteospermum moniliferum*, *Strelitzia augusta*, *Eugenia capensis*, etc., while *Mimusops caffra* associated with many others is dominant in the climax bush. Lianes are very numerous.

C. Barringtonia Bush. (*Barringtonia racemosa*, *Hibiscus tiliaceus*, etc.) This type occurs at the river mouths above the lagoons in wet, sandy soil, where the water is not brackish.

D. Hygrophilous Scrub and Forest. This is closely related to the corresponding tree veld, though only some of the species composing it are capable of growing isolated. The various species of Fig (*Ficus spp.*) are very characteristic. The Waterboom or Umdoni (*Eugenia cordata*) is often dominant. Other common species include *Rauwolfia natalensis*, *Voacanga dregei*, *Macaranga capensis*, *Combretum spp.*, *Pittosporum viridiflorum*, *Trema bracteolata*, with, at higher altitudes, *Ilex mitis*, *Erica spp.*, *Arundinaria tesselata*, *Widdringtonia dracomontana.*

E. Coastbelt Forest. *Protorhus longifolia*, *Albizzia fastigiata*, *Rhus laevigata*, *Milletia caffra*, *Trichilia emetica* are a few of the most prominent species in this type.

F. Midland Forest. The yellowwoods, *Podocarpus latifolia* and *P. elongata* are usually dominant associated with *Olea laurifolia*, *Ptaeroxylon utile*, *Olea foveolata*, *Xymalos monospora* (often dominant in moister spots), *Celtis rhamnifolia*, *Kiggelaria dregeana*, *Calodendron capense*, *Fagara davyi*, *Ocotea bullata*, and many others. Both in Coast Belt and Midland forest a host of smaller trees occur in the marginal zone of scrub.

G. Midland Dry Valley Scrub. (Karroid Scrub.) This is a very distinct formation which occurs in the driest areas in Natal,

e.g., the Tugela Valley and Lower Mooi River Valley. It is more xerophytic than climax Thorn Veld, though it does contain a sprinkling of Thorn Veld Acacias and other species. It contrasts very sharply with Midland scrub and forest. It resembles in some of its ecological characters the Fish River scrub in the Albany and Bathurst districts of the Cape Colony, and it has floristic connections with the vegetation of dry kopjes in the Transvaal as well as with the Tropics further north. According to Dr. T. R. Sim the component species can be arranged roughly in the following order of importance:—*Croton gratissimus*, *C. zambesicus*, *C. menyharti*, *C. rivularis*, *Vitex mooiensis*, *V. rehmanni*, *Heeria paniculosa*, *Euphorbia tirucalli*, *E. ingens*, *E. cooperi*, *E. tugelensis*, *Ficus natalensis*, and other species, *Tarchonanthus camphoratus*, *Capparis albitrunca*, *Schotia brachypetala*, *Ptaeroxylon utile*, *Clausena inaequalis*, *Euclea lanceolata*, *E. undulata*, *E. natalensis*, *Rhus* (many species), *Brachylaene elliptica*, *B. racemosa*, *Commiphora harveyi*, *C. caryaefolia*, *Dichrostachys nutans*, *Dombeya natalensis*, *D. rotundifolia*, *Aloe spp.*, with numerous climbing Asclepiadaceae, species of Clematis, etc. Parasitic species of *Viscum* and *Loranthus* are common.

H. Mountain (Drakensberg) Forest. In the scrub zone *Myrsine africana* is a frequent pioneer followed by *Erica spp.*, *Cliffortia spp.*, *Leucosidea sericea*, the last-mentioned often dominant over wide areas. The climax forest has *Podocarpus falcata* often dominant in South Drakensberg forests. *Curtisea faginea*, *Rapanea melanophloeos*, *Celtis rhamnifolia* are other characteristic species. *Olinia drakensbergensis* is found usually at higher altitudes than the others.

I. Ngoya Forest, Zululand. This type occupies a number of minor hills and valleys in the centre of a main range instead of the usual shales, sandstones and dolerites. *Milletia sutherlandi* is completely dominant while *Podocarpus* is rare.

8.—*The Alpine and Macchia Vegetation of the Drakensberg.*

This type has strong affinities with the South-Western vegetation of the Cape. The family Compositae is enormously abundant, while the Ericaceae are peculiarly characteristic, and ericoid growth forms belonging to other families, e.g., *Cliffortia*, *Passerina*, etc., are often dominant. It is best developed at altitudes of 8,000 feet and the usual effects of high altitude are shown in the gnarled growth forms, cushion forms, rosette forms, densely woolly coverings, etc., but the environmental conditions are so very unstable that all kinds of requirements are met in different spots. There are places with full exposure to the intense light, places with continuous natural shade and shelter; moist spots near the numerous dripping waterfalls contrast with very dry spots, it may be only a yard or two distant; places where frosts never occur may be quite close to places where the water is frozen into a sheet in winter. All this instability and complexity makes it difficult to sort out the vegetation into any system of ecological classification. The plant communities are as unstable as the environmental conditions. That

such conditions are peculiarly suited for the production of new species is shown by the large number of endemics which occur here. They are far in excess of any other part of Natal. They may be widespread along the range from north to south, but they do not occur at lower altitudes. Species seem to migrate readily along mountain ranges. This may be due also to the general environmental instability.

Plant Migration and the Affinities of the Natal Flora.

An analysis of the flora of Natal, family by family, brings to light the fact that it consists of two main important elements: (1) the Tropical and (2) the Temperate. The former might also be termed the "coast element" and the latter the "mountain element." The tropical element in the narrowest sense consists of species which actually occur in the tropics to the North. About 34 per cent. of the coastbelt flora is of this nature. From this purely tropical element a much larger sub-tropical element has been derived, including most of the species which are dominant over the midlands. The sub-tropical element extends also into the Cape Colony, though few real tropical species do so except as stragglers in favoured localities.

The purely tropical element is not confined to the coastbelt. It is also found further inland in the main river valleys (see Midland Dry Valley Scrub described already). The species in this inland tropical type are to a large extent distinct from those of the coastbelt, as they are in the tropics to the North, but to a certain extent there has been a migration inland, along the river valleys, of coastbelt species, e.g., in the case of *Dichrostachys nutans*.

The temperate element of the Natal flora, as already mentioned, is most characteristic of the mountains, particularly the great Drakensberg, which connects through the Stormberg and Karroo ranges with the South-Western Cape Colony and to the north with the high tropical ranges, right across the Equator and north to Abyssinia. The Macchia and Alpine vegetation of the Drakensberg is not only very similar to that of the Cape, but it is also in many ways closely connected with that of Kilimanjaro, Kenia, etc. The Drakensberg forms part of what may be looked upon as a great highway of migration from north to south or from south to north. At altitudes of 8,000 feet and more, the enormous numbers of Compositae, Ericaceae, Rosaceae (*Cliffortia*, *Leucosidea*), various bulbous Monocotyledons, etc., is to be contrasted with the absence or great scarcity of such families as Acanthaceae, Amarantaceae, Euphorbiaceae, etc., which are so abundant on the coastbelt. Tropical or sub-tropical species are, however, common and often dominant on the foothills and lower slopes of the Drakensberg below 8,000 feet.

Within the limits of a single family, such as the Gramineae, the same distinction may be drawn between Temperate and Tropical elements. The genera *Festuca*, *Poa*, *Avenastrum*, *Pentaschistis*, *Danthonia* are temperate in their affinities and are more or less

confined to the mountain regions of Natal, in contrast to the great *Andropogon*, *Panicum*, *Aristida*, *Eragrostis*, *Sporobolus* series which are so abundant at lower altitudes.

While the temperate flora of the Drakensberg and the tropical flora of the coastbelt and certain midland river valleys are clearly very distinct, the vegetation of the midlands as a whole is not so easily analysed. The dominant species in the subclimax and climax communities, i.e., in grassveld and in forest, are subtropical in their affinities. The grasses, trees, and shrubs are nearly all clearly to be connected with other purely tropical species. Very often coastbelt (tropical) species and midland (subtropical) species may be paired in a rather striking way. Earlier stages of the plant succession are, however, not so clearly tropical or subtropical. The vernal aspect societies in the grassveld are extraordinarily abundant, and comprise a very high percentage of the total flora. The Compositae and the bulbous Monocotyledons are by far the most important, and they are also best represented on the Drakensberg. It is true that they are common enough also on the coastbelt but not in the scrub and forest (the subclimax and climax vegetation) of the coastbelt. There they are relatively scarce. It would appear, therefore, that the earlier stages of succession in the midlands, including the numerous spring flowering plants of the grassveld, are to be reckoned as rather temperate than tropical in their affinities and to be connected with the mountain flora rather than with that of lower altitudes. This tentative conclusion would seem to be supported by the recent experimental work of MacDougall* in America on the interchange of species from one environmental complex to another. He found that species from cool regions may be more easily established in warm places than the reverse and montane plants may come to the seashore more easily than plants of maritime zones may spread over a mountain, and also that dissemination movements are seen to be freer from regions presenting climatic extremes to more equable climates.

Ecology, particularly from the successional standpoint, has many other useful applications apart from enabling one to classify the vegetation units, to understand, and often to control their development and to explain their distribution and their response to environmental factors.

The plants themselves, apart from the communities to which they belong, may be studied, compared, and classified, and the experimental developments of physiological ecology are full of promise.

Life Forms and Plant Succession.

The earliest attempts, such as that of Humboldt, at classifying the growth forms of plants were simply physiognomic. Resemblances were noted in the members of the same group, and heathforms, palmforms, grassforms, etc., were recognised. Of the

---

* MacDougall, D. T. "The Reactions of Plants to new Habitats." *Ecology*, II, 1921.

later systems, that of Warming has become the best known. He classified plants according to their water requirements, and his terms "hydrophyte," "mesophyte," and "xerophyte" have become familiar to every student of elementary Botany. Raunkiaer devised an interesting system by using, as his main basis of classification, the reaction of plants to the adverse season, a single factor which influences very greatly their general life history and growth forms. He also introduced a useful statistical method of comparing different climatic areas by estimating their agreement with or divergence from a "normal biological spectrum" for the whole world's flora. I have elsewhere applied his system to the flora of Natal.

The systems of Clements, Drude, and others each have points of interest, but time does not permit of further reference to them. All these systems agree in taking as the main basis of classification the plant's reaction to inorganic environmental factors. Those who have investigated the vegetation of their areas from the purely morphological or static standpoint without troubling about the developmental aspect, seek first of all to determine each plant's water requirements, soil requirements, etc. Those, on the other hand, who are keenly interested in the life histories of the plant communities not only try to assign each plant to its proper community as determined by habitat but, in the field, habitually ask themselves the questions, "What is this plant's exact place in the plant succession?" "Does it tend to be suppressed by or to suppress other plants?" and so on. It seems to me, therefore, that the time is ripe for the introduction of a scheme of classification based entirely on plant succession. Such a system takes into account not only the inorganic but also the living environment, that is, the plant's relationship to other plants, in a way that no other system does. It also, however, reflects the plants' response to other habitat factors as well, and not only a single master factor but them all collectively. It will be necessary to introduce one or two terms. Ecological nomenclature has been held up to scorn by more than one botanical author, but it is perfectly clear that for new ideas we must have new and definite terms, and we need not worry over much about those who will not take the trouble to understand them.

All plants belong either to early or later stages of the plant succession. For the former class the term "pioneer" is convenient enough but for the plants which follow after the pioneers—there is no good English term (I have elsewhere called them "subsequent species"). To bring these two classes into line with other life-forms we may use terms derived from the Greek, namely, "Prodophytes" and "Hepophytes." Prodophytes are primitive colonising species, which appear early in the plant succession, while Hepophytes are species which require to have the way prepared for them, and, therefore, appear later in the plant succession.

Further subdivision of these two classes is a very simple matter. It consists in determining the unit plant succession or "sere" to

---

* Bews, J. W. "The Growth Forms of Natal Plants." *Trans. Roy. Soc. of S. Africa*, V, 1916.

which they belong, e.g., Prodophytes in the xerosere (Xeroprodophytes) colonise bare surfaces and dry situations. Prodophytes in the psammosere (Psammoprodophytes) colonise sand. Prodophytes in the hydrosere (Hydroprodophytes) are the aquatic and marsh plants. Corresponding to each of those we have Xerohepophytes, Psammohepophytes, Hydrohepophytes. Recently a scheme of work has been planned and to a certain extent has been carried out at the Natal University College, consisting of a physiological—anatomical comparison of typical prodophytes and hepophytes. The work is still far from complete, and such results as have been obtained have still to be checked in various ways, but the following points may tentatively at least be put forward to illustrate the more important differences between the two classes:—

1. Prodophyes have more abundant and varied means of reproduction, both vegetatively and by means of seed, than hepophytes. Annual and biennial plants are usually pioneers, especially in secondary successions (subseres).

2. Prodophytes are adapted to more extreme conditions and are therefore either xerophytic or hydrophytic. Hepophytes are more mesophytic. Under very extreme conditions (of drought) the whole vegetation may be prodophytic. In that case the primitive stage of the succession is also the final stage.

3. Prodophytes are light-demanding and intolerant of shade. Hepophytes are shade bearers or intolerant of full sunlight, at least in their early seedling stages, though they often become more light demanding as they grow.

4. Prodophytes are more low growing than the hepophytes which belong to the same unit succession (sere). Many prodophytes are creeping forms, while the hepophytes grow erect.

5. Prodophytes are often more deep-rooted than the hepophytes which belong to the same sere.

6. The total number of prodophytic species is much smaller than of hepophytic. The largest number of hepophytic species, however, belong to intermediate rather than to final stages of the plant succession.

7. Prodophytes are more widely distributed geographically than hepophytes. (See Bews, *Annals of Botany*, 1920, p. 287.)

8. Prodophytes are somatically more plastic than hepophytes. Individual species of prodophytes show a considerable degree of variation in their structure and physiological behaviour, and are found, therefore, under a wider range of environmental conditions than hepophytes.

9. Prodophytes are influenced chiefly by the inorganic environmental factors, though the microflora and fauna of the soil is doubtless of importance. As soon as the succession advances far enough to bring the living environment (of other plants) into operation, prodophytes are ousted. For hepophytes the living environment is of the utmost importance.

10. Though somatically more plastic, prodophytes may be germinally more rigid than hepophytes. This would explain why new prodophytic species do not arise so frequently, and therefore why prodophytic species are less numerous. Prodophytes, however, probably often give rise to new species which are hepophytic and the reverse process may happen, also hepophytes producing prodophytes.

Many of these tentative conclusions require further testing. They illustrate, however, how by using this very fruitful comparative method, light can be thrown on the laws of communal development or succession. Such laws, once they are established, are clearly of the utmost importance. Had time permitted, I should have liked to indicate how by analogy such laws of plant succession supply fruitful ideas to those interested in the laws governing the development of human communities. In South Africa the pioneers (voortrekkers) can be compared with the men that belong to the more complex communities that have now been built up, and many interesting points are brought to light. That, however, is a subject which could be more appropriately dealt with by our friends in Section F. of this Association.

Addendum.

Since the above was written, in the last number of *Ecology* (Vol. II., 2, 1921) A. A. Hansen has published a short paper on "The Terminology of Ultimate Vegetation." He proposes the term "eschatophyte" for any member of an ultimate (or climax) vegetation. This term would not be synonymous quite with *hepophyte*, which includes plants belonging to intermediate as well as final stages of succession.

SOME RECENT ADVANCES IN ZOOLOGY AND THEIR RELATION TO PRESENT-DAY PROBLEMS.

By H. B. Fantham, M.A. Cantab., D.Sc. Lond.
Professor of Zoology, University of the Witwatersrand, Johannesburg.

Presidential Address to Section D, delivered July 11, 1921.

Introduction.

To prepare and read an Address to a Section of an Association for the Advancement of Science is no light task, especially in these days. A few months ago the columns of the scientific weekly, "Nature," contained many letters from scientists and ordinary laymen about the character of the addresses and papers read before the British Association for the Advancement of Science at Cardiff in August, 1920. The majority of the remarks were critical and somewhat derogatory, stating that the papers read were too abstruse or technical for the public and that the subjects chosen were not sufficiently "economic" in their application. Others wished Presidents of Sections to give reviews relating to the advances in their respective branches of science, instead of discussing subjects in their branch of science with which they were especially familiar or in which they were particularly interested.

Personally, I have decided to endeavour to meet some of these wishes, which apply to any and every country, by attempting a review of my branch of science instead of discussing with you various aspects of animal parasitology in which I am more particularly interested, and I readily agree that some attempt should be made to show how each branch of science can help us in our difficult present-day problems. As to emphasising or confining oneself solely to the economic or utilitarian aspect, while sympathising with the wish, yet a warning must be given that at the basis of national prosperity there lies something greater and deeper than mere economic or technical efficiency, that cannot be measured by the statistics of trade returns. Plato, centuries ago, wrote: "Man, if he enjoys a right education and a happy endowment, becomes the most divine and civilised of all living things; but he is the most savage of all the products of the earth if he is inadequately and improperly trained." Milton expressed himself on this matter thus: "A complete and generous education fits a man to perform justly, skilfully, and magnanimously all the offices both public and private of peace and war."

Science pursued for its own sake widens the outlook of the individual and trains his reasoning powers. "Pure science" must never be ignored, for the apparently academic and "useless" researches of to-day may be of the greatest technical benefit to-morrow. Examples of the truth of this in our own time are seen in the researches of Metchnikoff in 1884 on phagocytic cells in the blood of Daphnia, a transparent water-flea, when it was infested by a yeast-like parasite called Monospora. The phagocytes engulfed and digested the parasite. He had been working at phagocyte cells earlier (1880), having been led thereto by his observations on living jellyfish, sponges, embryos of Echinoderms and certain transparent floating Gastropods, while Professor of Zoology at Odessa. From these purely zoological studies he developed the great theory of phagocytes and their importance in relation to inflammation and the problem of immunity. Other examples are afforded by the work of Ronald Ross on the rôle of mosquitoes in the transmission of malaria, of Cailletet and Pictet on the liquefaction of gases, of Rontgen on the X-rays, and the early experiments of Marconi. Further, it is not for us to narrow the applications of science to the limits of our own horizons, otherwise we stultify real advances and limit ourselves to improvements in relative minutiae. Pure science—the pursuit of knowledge for its own sake—eventually gives a much greater and more comprehensive power of dealing with practical problems on effective lines than if the pursuit is narrowly tied to strictly utilitarian ends. Nature can only be effectively controlled when she is thoroughly understood, and this thorough understanding can only be obtained when she is studied for her own sake.

To attempt to review the recent advances in a subject like zoology is really to attempt an impossible task, for no one man can nowadays keep abreast of advances in comparative anatomy of animals, in cytology, in genetics, in animal parasitology, in oceanography and fisheries, and at the same time have interests of his own, that is, a corner of the subject on which he himself researches. However, I think I may be able to put forward some interesting and even practical information from such an attempted general survey of the work of zoologists during the last ten years, paying less attention to the older branches of the subject like detailed morphology and comparative anatomy, but dealing with the more recently studied branches of the subject. Of course no claim to completeness can be put forward, and the element of selection has necessarily entered into a compilation such as the review must largely be.

Before proceeding further, however, I should like briefly to express my views on the study of the subject of zoology. For the progress of the science, study of the living organism itself—its feeding, growth and reproduction—is essential. We must not forget the environment. Our methods must be those of observation and experiment before we can tabulate inferences. There is a danger nowadays of dividing the subject into relatively small

sections, devoted to studies with purely economic aims. The study of comparative morphology, including embryology and some histology, is indispensable. A knowledge of some animal life-histories is also required. Early specialisation is to be deplored. The specialist needs a breadth of outlook, an orientation in the whole field of his science, in order to have balance and perspective, which are absolutely necessary.

Animal Parasitology.

In this subject, which is a vast one, we may first note the use made of protozoologists, helminthologists, and entomologists in the Great War, more especially in America, where they were given military rank. Thousands of examinations of blood smears for malarial parasites, of stools for parasitic Protozoa and helminthic ova, and experiments for the control of lice and of flies—to name but two insects—were made. Several strains or pure lines of *Entamoeba histolytica*, sometimes called *Endamoeba dysenteriae* in America, the causal agent of amoebic dysentery, were definitely indicated as a result. In malaria the continued use of quinine for three months after apparent recovery from malaria was indicated. In helminthology, after the work of Japanese scientists regarding the stages of *Schistosoma* (*Bilharzia*) *japonicum* in snails, Leiper determined the Gastropod hosts of *S. haematobium* and *S. mansoni* in Egypt, and Porter, Cawston, and Becker have worked at the problem in South Africa. Porter has now determined the life-cycle and molluscan hosts of *S. haematobium* and *S. mansoni*, and incidentally those of the African cattle fluke, *Fasciola gigantica*. as well as those of *F. hepatica* in South Africa.

The actual nature of the organism causing typhus, which is transmitted by lice, still baffles us. But, being certain that it is lice-borne, we now know an effective way of attacking typhus by de-lousing campaigns, just as earlier, thanks to the labours of Sir Ronald Ross, we know that anti-mosquito measures against Anophelines will control malaria. Also, thanks to American investigators, we know that anti-mosquito measures against *Stegomyia fasciata* will control yellow fever. The causal organism of yellow fever is stated by Noguchi to be a spirochaete, *Leptospira icteroides*.

In Africa there is still a most important economic entomological problem to be investigated further, namely, the bionomics of Glossinae or tsetse flies and their relation to big game, in order to control various forms of trypanosomiasis, such as sleeping sickness in man and nagana in cattle. In 1910 a second human trypanosome, *T. rhodesiense*, was discovered.

In protozoology important researches, affording interesting evidence in the evolution of disease, have been carried on by Laveran and Franchini and by Fantham and Porter, who experimentally introduced species of *Herpetomonas* into various vertebrates. Leishmania in culture shows that it is a Herpetomonas, and the experiments mentioned, on induced herpetomoniasis, show that Leishmania is an insect-borne Herpetomonas which can live

in some vertebrates, such as men, dogs and mice, in a state of more or less disharmony causing disease.*

Though hardly parasitological, it may be mentioned that the Protozoa found in soil are being examined, and their relationships with bacteria and possibly with the fertility of the soil are being investigated in England, America, and South Africa.

Important work on Nematodes, their life-histories and their effects on the growth of agricultural food-plants—such as wheat, potatoes, and tomatoes—on domestic cattle and on man has been, and is still, in progress. Such work is being done in South Africa, and mention may be made of the important work of Dr. F. Veglia on *Haemonchus contortus*, the wire-worm of sheep.

The Rockefeller Foundation for medical research, through the agency of their International Health Board, have performed magnificent work in the treatment of patients suffering from ancylostomiasis (hookworm disease) in many countries.

Very interesting and useful work has been done by entomologists in endeavouring to find natural enemies or parasites of noxious insects.

Animal Physiology.

Much work has been done on the ductless glands or endocrine organs and the effects of their internal secretions. We may notice with interest some researches on the thyroid gland in the lower vertebrates, especially the Amphibia. Tadpoles fed with mammalian thyroid metamorphosed weeks before the control animals. For example, *Rana catesbiana*, which normally takes two or three seasons in its metamorphosis, only takes one month if fed on thyroid. Surgical removal of the thyroid arrests metamorphosis, the tadpoles remaining as larvae though their reproductive organs continue to develop. The active principle of the thyroid has been isolated, and is called thyroxin. It is an iodide of an indole propionic acid, and the activity of the gland varies directly with its iodine content. It has been suggested by Swingle and supported by Uhlenhuth that amphibian metamorphosis is due to the interaction of different environmental agencies. Uhlenhuth suggests that there is a reciprocal relation between the activities of the parathyroids and thymus, in that the former absorb a tetany toxin made by the latter. The inter-relationships of the endocrine

* Since this was written Mrs. Helen A. Adie has published a short paper in which she states that there is an intracellular stage in the development of the Leishman-Donovan body occurring in the cells of the gut-wall of the bed-bug, *Cimex lectularius*, and similar to that of *Trypanosoma lewisi* in the stomach-epithelium of the rat-flea. It is stated that Major W. S. Patton has confirmed this intracellular stage of *Leishmania donovani* in the bed-bug. "Indian Journ. Med. Research," IX, pp. 255-260, October, 1921). Patton, himself, contributes a short note on his findings on p. 251 of the same Journal, where he states that the intracellular stage of *Herpetomonas (Leishmania) donovani* occurs in the mid-gut of *Cimex hemiptera (rotundatus)* and that *Leishmania tropica* has a similar intracellular stage in the same insect, showing that the bed-bug is a true invertebrate host of these parasites. Mrs. Adie (Nov., 1921) has also found Leishman-Donovan bodies in the salivary glands of *Cimex rotundatus*.

organs are also indicated by hyperpituitarism and hypertrophy of the parathyroids apparently resulting from thyroidectomy of amphibian larvae. Pineal secretion seems to react on the chromatophores or melanophores of the skin, causing them to contract, and so producing striking temporary changes in colouration, which is not without interest when the archaic function of the pineal body as an eye structure is remembered.

The present author found that fresh extract of sheep's thyroid gland induced rapid division of trypanosomes in vitro, more rapid than the normal.

Fisheries Work.

Fisheries development has received considerable attention during the last few years both in Europe and America, while a new beginning has been made recently in South Africa. Such developments have, in many instances, been made possible by purely scientific work, undertaken with no idea of immediate economic application. Thus, the development of the great north-western fishing grounds of Great Britain resulted from the endeavours of Wyville Thomson and others to determine the presence or absence of life in the deep sea.

Work on the life-history of flat fish, e.g., plaice and soles, has led to transplantation on a large scale off the English coasts, and fish hatching experiments, similarly, have led to the stocking of inland waters in America, resulting in great increase of the available food of the people. A start has also been made in South Africa, and the trout hatcheries have done useful work.

Commercial use has been made of the scientific investigations of the life-histories of crabs, lobsters and crayfishes, and large canning industries have arisen therefrom. As a result of the investigations mentioned, protection laws have been enacted with regard to females in berry, the enforcement of the said laws preventing the destruction of ova, with subsequent increase in the bulk of Crustacea available for human food. Similarly, scientific work on the life and habits of oysters and mussels permitted of the utilisation of a hitherto neglected source of food supply.

Again, the study of larval stages of molluscs has led to the establishment in America of numerous freshwater mussel fisheries, providing nacre for pearl buttons, and of pearl-shell farms in the Red Sea.

Much attention has been given by zoologists to the subject of the physico-chemical environment of organisms and its influence on the observed variations of animal and plant life in the sea. It is known that there are seasonal variations in the marine plankton; but the causes of this periodicity are not known with certainty. The warm waters of the tropics are said to support a less abundant plankton than the cold polar waters. Probably to be correlated with this is the observation that the nitrogen concentration in tropical waters is low, being higher in cold waters. Again, the hydrogen-ion concentration, as tested by the relative degree of alkalinity or acidity of sea-water, has been investigated in relation

to marine life. Alkalinity has been found to be low in summer, to increase somewhat in autumn, to disappear in winter, and to reappear again in spring (March) at Port Erin, Isle of Man, reaching a maximum in April or May. This change corresponds roughly to the change in the phyto-plankton observed there. It has been shown also that the diatoms increase in numbers when the water is at its coldest, and these are followed by swarms of Copepods. The number of Copepods in a given area determines the presence or absence of swarms of fish, such as herring and mackerel, that prey on them. As Crustacea feed largely on diatoms and flagellates, a knowledge of the distribution of these may be sufficient to initiate new enterprises in fishery work.

It is well known that the great intermediate zone of waters between surface and bottom used to be considered lifeless. Thomson's work, to which reference was made earlier, showed that this was not the case. Recently, according to arguments advanced by A. H. Church, such a zone of waters has a special evolutionary interest, since it was possibly from a former world-wide ocean of ionised water that the first living organisms were evolved to become later the floating unicellular plants of the primitive plankton.

Cytology and Sex.

An enormous amount of work has been done on cytology during the last twenty years. Among the pioneers mention may be made of Boveri and E. B. Wilson. It is quite impossible even to attempt to outline this work. Perhaps notice of some recent work may suffice before we pass on to consider work on chromosomes and sex.

Outside the nucleus of the cell and within the cytoplasm are the Golgi apparatus and mitochrondria. Within the nucleus in addition to chromosomes are nucleoli. The nucleoli are either plasmosomes or karyosomes. The independence of the nucleolus and the chromosomes has been shown in the division of the cell. The nucleolus is an important element in the cell, being concerned with important metabolic functions. Gatenby considers the nucleolus to represent trophochromatin and the chromosomes to represent the gonochromatin.

Most interesting and promising advances have arisen from studies of the chromosomes of the germ cells of certain animals, especially in connection with Mendelian experiments with hybrids. The chromosomes are stainable bodies in the nucleus of a cell, especially of a germ cell, that carry hereditary characteristics, both physical and mental, from the parent to the children. Formerly it was thought that the chromosomes of the germ cells of the two sexes were the same in number. However, an accessory chromosome was discovered by several observers, who found that in the males of certain insects belonging to the Hemiptera and Orthoptera there was one chromosome that behaved differently from its fellows during maturation or reducing divisions. This chromosome took no part in the pairing of the maternal and paternal chromosomes, but passed undivided to one pole of the division spindle,

when migration of the other chromosomes to the poles occurs. In consequence the resulting spermatozoa were of two kinds, namely, those possessing the accessory chromosome and those lacking it. As long ago as 1902 McClung, one of the first observers of this phenomenon, suggested that the accessory chromosome was the determining factor in sex. The famous American cytologist, Professor E. B. Wilson, and others followed up this matter, and found that the accessory or X chromosome, as it began to be called, was paired in the female. The two X chromosomes in the female behave in a general or normal manner, so that all eggs after maturation contain a single X chromosome. As a consequence, at fertilisation two classes of eggs are produced—(a) eggs fertilised by a spermatozoon carrying the X chromosome, and (b) eggs fertilised by a spermatozoon carrying no X chromosome. Two kinds of zygotes (as the fertilised eggs are called) will be produced, namely (a) zygotes with what has been called XX constitution, and (b) zygotes with X constitution. Furthermore, the highly interesting result follows that the first type of fertilised eggs or zygotes develop into females and the second type into males.

During the early period of the investigations other Hemiptera were found by Wilson to exhibit further chromosome peculiarities, wherein the X chromosome of the male was accompanied by another, a mate, called the Y chromosome, usually much smaller than X. It was found that the X and Y chromosomes conjugated during maturation, so that half the resulting sperm contain the X chromosome and half contain the Y chromosome. The X containing sperm are female-producing, the Y containing ones are male-producing. Morgan's work on the fruit fly, *Drosophila ampelophila*, revealed some most interesting characters illustrating this principle. In this fly a number of new characters have appeared suddenly, by mutation, and their inheritance can be studied, since the fly breeds rapidly. Morgan's researches on eye colour in this fly may be described best in his own words, thus: "Certain factors follow the distribution of the X chromosome and are therefore supposed to be contained in them. These factors are said to be sex-linked. The inheritance of white eyes may serve as an illustration for the entire group of sex-linked characters. If a white-eyed male is bred to a red-eyed female (wild type), the sons and daughters (F_1) have red eyes. If these are inbred the offspring (F_2) are three reds to one white, but the white-eyed flies are all males. If we trace the history of the sex chromosomes we can see how this happens In the red-eyed mother each egg contains an X chromosome bearing a factor for red eyes. In the white-eyed father half of the spermatozoa contain an X chromosome which carries a factor for white eyes, while the other half contain a Y chromosome which carries no factors. Any egg fertilised by an X-bearing spermatozoon of the white-eyed father will produce a female that has one red-producing X chromosome and one white-producing X chromosome. Her eyes are red, because red dominates white. Any egg fertilised by a Y-bearing spermatozoon of the white-eyed father will produce a son that has red eyes, because his X chromosome

brings in the red factor from the mother, while the Y chromosome does not bring in any dominant factor. At the ripening of the germ cells in the F_1 female the number of chromosomes is reduced to half. There result two kinds of eggs, half with the red-bearing and half with the white-bearing X. Similarly in the male there will be two classes of sperm, half with the red-bearing X chromosome, half with the indifferent Y chromosome. Random meeting of eggs and sperm will give . . . a 3 : 1 ratio, as in other Mendelian crosses, but the white individuals in F_2 will be males. The factor for red in the F_1 male will always stay in the X chromosome, so that all the female-producing spermatozoa will carry red, and consequently all F_2 females will be red. The males will have red eyes if they receive the red-bearing chromosome from their mother and white eyes if they receive the white-bearing chromosome from their mother.

The reciprocal cross is made by mating a white-eyed female to a red-eyed male. The daughters will have red eyes and the sons white eyes. If these are inbred their offspring will be red and white in equal numbers, and not the usual three reds to one white."[5]

In Lepidoptera and birds there is a surprise as regards sex chromosomes, for the usual conditions are reversed. The eggs are male and female-determining, not the spermatozoa, as the sperm are alike and the eggs are different as regards accessory chromosomes.

The sex-chromosome hypothesis explains sex-limited inheritance, such as colour blindness (commoner in males) and haemophilia.

Turning now to man, it is of interest to note that in the negro, according to Guyer and to Montgomery,* there is only half the number of chromosomes found in the white race. In the latter the somatic number is 48 in the female and 47 in the male.

Most interesting work has been done by Alan S. Parkes on "Sex heredity with special reference to the abnormal numerical inequality between the sexes." Investigations on the subject have taken two lines, first, breeding experiments and pedigrees of families showing sex-limited characteristics, and second, cytological research where "a physical factor was looked for as an elaboration of the chromosome theory." The supernumerary pair of chromosomes, or a pair in one sex and one—or one and a vestigial one—in the other sex, provided the explanation. The result has been to establish that man is grouped with the higher animals and with the Drosophila fly in possessing heterozygous males and homozygous females. The inclusion of man is based on the study of sex-limited charac-

* Since writing the above my attention has been drawn to a letter by T. S. Painter in "Science," May 27, 1921, who accepts the results of H. von Winiwarter as regards the number of chromosomes in man (approximating to 48), and apparently finds no difference in number for whites and American negroes. Unfortunately Painter does not appear to have followed up his work by a more complete publication, and it is hardly a correct procedure to rush into print with a mere letter on such an interesting matter, without stating his evidence more fully.

teristics. Parkes has now worked out the cause of the preponderance of one sex over another by genealogical investigations. Race also appears to be a factor. He states that "among the Jews, no matter in what part of the world they may happen to be resident, there invariably occurs a much greater normal excess of male births over female than is the case with Christians." Also, during the recent war, the ratio of male to female births rose steadily and persistently. It may be assumed that the war was in some obscure way beneficial to the welfare of the Y gametes. Also, "fluctuation in the number of male births per 1,000 female during the last century follows almost exactly the rise and fall in the economic price of food. . . . It is impossible for sex to be altered by nutrition after conception, so . . . we conclude that higher economic prices, and, consequently, more hardships, are capable of affecting the gametic ratios of the heterozygous sex, and of altering it in favour of the gametes with the male potentialities."

Parkes' family analyses supply direct evidence that in man the male is heterozygous for sex, while the female is homozygous. The female has no determining influence on the sex of the offspring, and the characteristic of begetting a preponderance of one sex over the other is an attribute of the male.

The Processes of Evolution.

Evolution may be defined as the gradual differentiation of organisms from common ancestral forms. It is the only reasonable explanation of the diversity of fossil and living beings. In enquiring into the mechanism of evolution we must consider the reciprocal influence—or action and reaction—of agents external to the organism on the one hand and of the living substance itself on the other. The external factors together constitute the environment and the internal factors are the specific properties of the organism. The environment is the more easily analysed. The two principal hypotheses proposed to explain evolution were both based on the efficacy of external factors, namely, the hypothesis of Lamarck in 1809 and the hypothesis of Darwin in 1859. Lamarck's hypothesis begins with the conception that the structure of organisms is in harmony with the conditions under which they lived and that it is adapted to these conditions. The organism is shaped by the environment. Usage develops the organs in the individual and without usage they become atrophied. The modifications thus acquired are transmitted to posterity, i.e., acquired characters are inherited. Lamarckism looked to the very cause of the change or variation among organisms by its method of explaining adaptation.

Darwin in his later life admitted the theoretical importance of adaptation and the inheritance of acquired characteristics, but placed them in a position of secondary importance in the accomplishment of evolution. Darwin found a basis in the variability of organisms which he accepted as an observed fact, without trying to discover the cause of variations. The individuals which possessed advantageous variations under the conditions in which they lived had more chance to survive and to reproduce themselves.

There is established a natural selection, i.e., a choice which perpetuates the advantageous variations and eliminates the others.

Among Neo-Lamarckians, A. Giard accorded to natural selection the value of a secondary factor. Among the Neo-Darwinians we have Weismann, who believed in the continuity of the germ-plasm, denied all value to Lamarckian factors, and saw in selection the predominant factor in evolution. Such was approximately the state of affairs at the end of the 19th century. In this, the twentieth century, however, two kinds of investigation have developed, namely, the methodical study of variations and the systematic study of heredity, especially of hybridisation. The two kinds of investigation overlap. De Vries (1901) studying the Evening Primrose (*Oenothera lamarckiana*) considered that he found new species suddenly arise by saltations, and to these sudden appearances he gave the name mutations. Further study has led to the distinction of two kinds of variations, namely: (1) small casual ones called fluctuations produced under the influence of the environment but not hereditary, and (2) large discontinuous variations or mutations, not directly dependent upon the environment but upon heredity. It may be added, however, that some of the most recent investigations indicate that the distinction between these variations must not be too greatly emphasised. The important new branch of biology termed genetics has arisen from these studies.

In these important researches the reconsideration and extension of the valuable work of Abbot Gregor Mendel on hybridisation, announced in 1865 but overlooked until 1900, has formed a basis. The fundamental principle of Mendel's results was that the unit characters or factors contributed by two parents of a cross separate in the germ cells of the offspring without having had any influence on each other. For example, Mendel himself worked on crossing different varieties of the garden pea. He found that of certain contrasted couples of parental characters or factors, such as tallness and dwarfness, which did not blend, one was dominant over the other, which was latent or recessive. The first generation of hybrids was apparently all dominant, but it was subsequently found that they were really impure dominant. When these hybrids were inbred it was found that one-quarter of them reverted to the dominant type, one-quarter to the recessive type, while one-half reproduced hybrid features, and that these proportions were maintained when the impure dominants were again inbred. The inbred offspring of pure dominants and pure recessives bred true. More than one pair of contrasted characters or factors may differ in parents. In crossing, the two pairs of factors segregate independently of each other, and the ratio 9 : 3 : 3 : 1 is characteristic of dihybrids when one member of each pair of characters is dominant. Strict supporters of these principles consider that Mendelian factors are unchangeable.

Again, reference should be made to the work of Johannsen in 1903 and onwards on self-fertilising pure-bred plants like beans, where there is a continuation of one and the same line, for the

same hereditary substance is perpetuating itself through a series of generations. To such a group of individuals, produced in the manner indicated and roughly similar to one another, without tendency to break into types, the term "pure line" has been applied. If the pure-line hypothesis is absolutely correct, then selection within a self-fertilised family has no result. Johannsen's ideas favour the view of the constancy of factors, as held by Mendelians. Karl Pearson, however, has shown that Johannsen's results were not conclusive.

Dr. Warren, in South Africa, experimenting with foxgloves and nasturtiums, obtained results which do not favour the pure-line hypothesis. He found that the fluctuating variations are inheritable, not as stated by the Mendelians, and that the factors handed down to the fertilised germ-cell are not constant, but are variable in nature. He concludes that "the smallest variation may be inheritable, and can be utilised in the course of evolution."

Although the researches of Morgan and his collaborators in America on chromosomes as bearers of the hereditary material have been interpreted in Mendelian terms, yet recently these interpretations have been challenged, notably by W. E. Castle and by H. S. Jennings. We must therefore endeavour briefly to consider the brilliant researches of T. H. Morgan, which were largely done on *Drosophila ampelophila*, the fruit fly or pomace fly. This fly breeds quickly. Much consideration was given to eye colour. The eye is normally red, but various mutations appeared during the investigation, thus one mutation showed white eye colour, another eosin eye colour, and there were found ultimately seven grades of colour due to changes in the X chromosome. This is an example of a single unit factor with many grades. Morgan and his collaborators belong to the Mendelian school. The seven grades of eye colour on the mutation hypothesis are explained by "multiple modifying factors." The grades of colour are thought by them to be essentially discontinuous, but the steps in the series become minute, and in the end barely detectable. Bridges, continuing the work, found seven secondary grades within one of the primary ones. We must also mention the important researches of W. E. Castle, especially those on hooded rats, showing graded results of the amount of colour in the rat's coat in biparental inheritance. Castle explains the graded coat colour in rats and the graded eye colour in Drosophila not as the working out of Mendelian recombinations of mosaic-like parts, but he believes in actual alterations of the hereditary constitution, indeed, an actual change in a single-unit factor, and that in rats he can by selection gradually increase or decrease the amount of colour in the coat, passing by continuous stages from one extreme to another.

H. S. Jennings holds much the same views as Castle. Jennings worked on Paramoecium and on *Difflugia corona*, where he found that a particular stock or strain resulting by fission from a single parent, does differentiate gradually, with the passage of generations into many hereditarily diverse strains. Most of these hereditary variations were minute gradations, and "variation was as

continuous as could be detected." Similar conclusions were reached by R. W. Hegner.

Castle wisely remarks that mutation and pure lines have a limited applicability in the broad field of organic evolution. He thinks that through selection or after selection a Mendelian unit character can be changed. Selection may not be able to start new lines of variation, yet it can continue and extend variation already begun. Warren's work, already noted, has the same conclusion. We thus see that, although during the last few years the importance of the rôle of selection in evolution has declined in favour and has even been doubted, largely due to De Vries' work on mutations and to Johannsen's work on pure lines, yet according to Jennings and to Castle the discontinuous variations ultimately become continuous and selection is a process in evolution after all.

Jennings sums up the matter thus: "Evolution, according to the typical Darwinian scheme, through the occurrence of many small variations and their guidance by natural selection, is perfectly consistent with what experimental and palaeontological studies show us; to me it appears more consistent with the data than does any other theory."

In the last sentence the evidence from palaeontological studies was mentioned. Following Osborn, as interpreted by Jennings, it may be stated that in palaeontology the evidence is for evolution by minute, continuous variations, which follow a definite trend or course. There are, however, other variations from the line of definite trend.

Another palaeontologist, Dr. Bather, in his address on "Fossils and Life" before the British Association last year, states that in organisms the "changes of form are a reaction to the stimuli of the outer world." He favours the view that "the life history of races is a response to their environment." The "environment changes slowly and the response of the organism always lags behind it." A living organism cannot be conceived apart from its environment. Palaeontologists nowadays are the chief opponents of the hypothesis of discontinuity.

Osborn expresses the Lamarckian explanation of the processes of evolution in modern terms thus: "The causes of genesis of new form and new function are to be sought in the body cells." He expresses the Darwinian explanation in the following terms: "The genesis of new form and function is to be sought in the germ cells or chromatin." These interpretations are probably much more sharply distinct or antithetical than Lamarck or Darwin would have made them, or even than the problem, being one of living organisms, warrants. Now that we know of hormones, or internal secretions, it is possible that such secretions of certain parts of the soma, when affected by external stimulation, may affect the germ cells. It may be stated then that selection may take place through the action of external conditions. Indeed, MacBride writes that "selection alone, when the environment remains constant, is powerless to effect evolution."

It will now be well to consider Lamarckism, including the belief in the inheritance of acquired characters, from modern aspects.

The hypothesis of the inheritance of acquired characters is championed in Britain by MacBride. Early this year he published an interesting review on the subject in "Science Progress." This hypothesis implies that changes in habit and environment produce an effect, not only on the animals directly exposed to them, but also on their offspring. The changes produced by an altered environment are an expression of the response or reaction of the animal in its endeavour to adapt itself to changed circumstances. By the inheritance of acquired characters is meant the inheritance of the effects of use and disuse. We may note some of the interesting researches, many of them experimental, published recently in support of this hypothesis.

Kammerer working in Vienna has carried out a series of experiments chiefly on Amphibia. One set of experiments was on European salamanders. The yellow salamander, *S. maculosa*, inhabits the lowlands and gives rise to 30 to 40 gilled young. The black salamander, *S. atra*, lives at high altitudes and gives birth to only two young. The gilled young of *S. maculosa* live in water for six weeks before losing their gills and changing into the land form. The young of *S. atra* are born as terrestrial animals, ready to take up the mode of life of the parent. However, if a pregnant black salamander is opened, at least a dozen embryos are found inside, but only two embryos are destined to survive, for the others degenerate to form a fluid that serves to nourish the two. The two lucky embryos possess long gills, but these gills are absorbed before birth. According to MacBride, Kammerer asserts that "if *S. atra* be gradually accustomed to live under warmer and moister conditions she will begin to produce first three and ultimately four young at a birth, that these young will enter the world at an abnormally early period of development —even before the gills are fully absorbed; that if these young be reared to maturity under the same conditions they will give rise to still more young at a birth, and these young will be provided with gills, and will take to the water—in a word, that *S. atra* can be induced to assume the habits of *S. maculosa*, and that these habits will be transmitted to posterity." Kammerer has also performed the reverse experiment. He finds that if *S. maculosa* is subjected to increasing cold and dryness, it produces fewer at a birth, and these are born in a more advanced state of development. In three generations only three or four are born at one birth, their gills are mere stumps, the gill clefts are closed, and the animals can live on land. *S. maculosa* has apparently acquired the habits of *S. atra*.

Kammerer has also experimented with the midwife toad, *Alytes obstetricans*. Alytes differs from other toads in that it pairs on land, and the male does not develop a horny pad on the hand. The eggs are larger and fewer in number than in the case of ordinary toads. The male carries the fertilised egg-strings round

his legs and hops away encumbered with them. Some weeks later he visits the water and the eggs are hatched. The emerging tadpoles have already covered up their gills. Kammerer provided adult Alytes with a tank for bathing. They began to pair in the water. Under this circumstance the eggs slipped off the male's legs and remained in the water. Only a few of them survived. But the toads hatched from these eggs paired in the water. The females laid smaller eggs and the tadpoles from them had external gills, but only one on each side. However, the third generation of Alytes raised in the water produced eggs that gave rise to tadpoles with three external gills on each side as in ordinary toads, while the males had horny patches on their hands. By further experiments it was found that the horny pad increased in size and definiteness up to the fifth generation. Bateson has questioned some of Kammerer's work.

Further interesting experiments noted by MacBride are those of Guyer and Smith, published in 1920. These observers worked on rabbits. The lenses of the eyes of rabbits were pulped in Ringer's solution, and the fluid injected into domestic fowls. After a few weeks an antibody developed in the fowl's blood. Fowl serum containing the antibody was injected into pregnant rabbits. The mothers were unaffected, but some of the young showed diminished or aborted lenses to their eyes, and correspondingly developed retinae. Many of the young with imperfect eyes died, but some survived. These mated together gave rise to young, some of which showed the defect, and this defect was observable through six generations without any further injection of serum. Two instances of inheritance through the male alone were noted. The defects once established became more pronounced in successive generations. Guyer and Smith suggest that "the degenerating eyes are themselves directly or indirectly originating antibodies in the blood serum of their bearers—which in turn affect the germ cells."

We have now briefly reviewed some of the modern ideas on the processes or modes of evolution. In the past too much appears to have been made of differences between the various hypotheses put forward to explain the processes. Ruggles Gates has suggested that the higher organisms exhibit two types of characters, namely, cell characters arising as mutations, and organismal characters (environmental or orthogenic) which may modify localised parts of the life cycle. We have seen how the views of Jennings and Castle indicate the merging of mutations and continuous variations. Possibly through the agency or interaction of internal secretions or chemical messengers, as yet perhaps not fully understood, the various discrepancies in the hypotheses may be reconciled and their inter-relationships demonstrated.

Application to Present-Day Problems.

The outstanding features all over the world to-day are the struggle between nations closely linked with the struggle between Capital and Labour. Statesmen are powerless, leaders are not obeyed. Moderate opinion is swamped by extremes and exaggera-

tion. The causes for these deplorable conditions are perfectly obvious, but we have not time now nor would it be our province to discuss them. Nevertheless, our social and educational problems have suffered too long already at the hands of the biologically untrained, while surely in the whole matter of human heredity or eugenics the biologist is clearly the one to lead the way.

A League of Nations has been launched by learned and earnest men as a means of settling disputes and ending wars. Unfortunately these learned and earnest men who launched this beautiful idea—for it is beautiful—were not too well acquainted with biology. They forgot the environment, they proceeded too quickly and too idealistically, they forgot human nature, they forgot the protoplasm or living substance in their eagerness to mould an ideal environment. Man is an animal and he is subject to the same laws as other animals. Nations and peoples must be educated slowly and carefully, yet *naturally*, to respond to such an ideal conception. A mere committee, comfortably seated in armchairs, with a capable secretariat and careful agendas for meetings, realises little or nothing of the action and reaction of living substance and environment. Lawyers and politicians, unfortunately, scarcely realise this, almost the fundamental basis of life. Why do not the Supreme Council, or the League of Nations, or whatever other Council is really concerned—unfortunately there are too many of these exalted bodies—realise that in the matter of, say, Upper Silesia, they should give a decision and avoid delay and so not allow this irritant to remain in Europe. One of the characteristics of living matter is response to stimuli, and it is called irritability. The simple characteristics of living matter need to be studied by rulers, ambassadors, administrators, lawyers. I venture to think that had all the representatives on the Council of the League of Nations a knowledge of the reactions of a speck of living matter like an Amoeba, inhabiting pond water, to stimuli, such as a drop of weak acetic acid, it would probably do more good to the world than all the notes and pious resolutions ever composed. Whitehead has already written of the likelihood of men of science being called from their laboratories to regenerate the State. We hear much of how Science won the war. We may possibly hear of how science is making the world a better place to live in, but do we clearly understand that in scarcely any part of the British Empire are scientists present in the Cabinet?

Again, man is said to differ from the so-called brute creation by the possession of consciousness as opposed to instinct, in other words, by being capable of conscious intelligent action leading to higher aspirations or ideals. In the past these higher ideals have often been called religion. To-day we hear insistently about the workers needing to obtain a higher standard of living. In practice this higher standard of living for many is merely undisciplined amusement, indulgence in luxuries and excitement, with the higher mental faculties starved. After a time the excitement tires the poor living substance, and dissatisfaction ensues with all its attendant ills and misfortunes. It cannot be doubted that religion

or idealism is necessary to all, and is essential to human progress. As Tansley in his book, "The New Psychology," writes: "If all religious tradition had been destroyed at any given moment and a new generation brought up in ignorance that it had ever existed, it can scarcely be doubted that a new religion, of substantially the same type, though varying in form according to the epoch, would have appeared."

The old dogmatic religions have failed; they were not in reality religions. Unfortunately religion and science appeared to quarrel irreparably over Darwin's enunciations some 60 years ago. The clergy are usually educated in lack and ignorance of the principles of biology, many of them being convinced that a biologist is an "infidel." This can quite easily be altered by the gradual teaching of animal biology in schools and by making a course in the elements of evolutionary biology a necessary part of of *every* University curriculum. Let this course contain instruction in the characteristics of living matter, a knowledge of the various great groups of animals stated in simple language with a due insistence on environment and habitat, a knowledge of a few simple life-histories (such as of the fly or the frog), a knowledge of Darwin's patient work with pigeons and with earthworms, all simply told, with natural examples in use in every case. The life story of the frog may be used to introduce the recapitulation hypothesis and the idea of evolution. Some of the researches of the great workers at the problem of evolution may be discussed, thereby giving knowledge of the work of Mendel on hybrids, the more recent work of Bateson and Morgan in continuance thereof, the use-inheritance ideas of Lamarck and the recent work of Kammerer. Perhaps the idea of cells may be inculcated, leading to some idea of chromosomes, the carriers of hereditary characteristics. Whatever is attempted must be graphically described and illustrated from life. Examinations and text-books with their dogmatic and uninspiring statements should be used as little as possible. Some of the subjects I have mentioned are not only fascinating but fundamental to living beings. They appeal to the higher mental faculties. They lead unconsciously and gradually to the idea of a First Cause. There is then no longer antagonism between science and true religion. The story in the first chapter of Genesis can be looked upon as an allegorical account of geological epochs, suited in character for understanding by primitive peoples at first unacquainted with the principles of science. Even the statement in Chapter 2, verse 7, that "God formed man of the dust of the ground and breathed into his nostrils the breath of life," may be considered as an allegorical statement of a scientific principle. Much speculation has arisen as to the origin of life, as to the character and relationship of the first living substance. I agree from the results of my own researches on Bacteria, Spirochaetes, and lowly Protozoa with the late Professor Minchin that the primitive substance was probably chromatin, the stainable, nuclear substance of cells, which in the germ cells carries the hereditary characters. Before cells, as we understand them to-day, with their chromatin and cytoplasm were

evolved, it seems to me that chromatin in the form of specks or granules, as "dust," to use the Biblical expression, was the first living substance, probably secreting around itself a slight covering of cytoplasm. Probably we have in the filterable or ultra-visible viruses, such as are responsible for scarlet fever, primitive organisms not far removed from the earliest and simplest living organisms. There are probably free-living, ultra-visible viruses, even in the sea, where life began. Bacteria, although many of them are degraded by parasitism, may represent to-day a stage in evolution between the primitive organismal granule and simple unicellular plants and animals forming a primitive plankton. The Biblical statement that God breathed into man, formed from dust or organismal chromatin, the breath of life may quite correctly imply that the chromatin granules, carrying the hereditary characters, came from God, and so the hereditary characters may have originally come from God, which explains the Biblical statements, often affirmed in varying terms, that man is in the image of God, many intervening evolutionary epochs being assumed. Regarding the doctrine of immortality, we have in the germ cells of the body "a cellular autonomous immortal line" continuous through successive generations.

We read frequently in the Scriptures of "sin," and it forms, or did form, an almost never-ending theme on the part of divines. Probably the preachings of the doctrine of "sin" did more to loosen the hold of the orthodox religions on the masses than any other theme. However, "sin" can quite easily be explained scientifically as "disease." We now know that when an organism which has become parasitic is out of harmony with its host (i.e., its environment) it will probably be disease-producing. This may account for the old ideas of sin and punishment by plagues. The visiting of the "sins of the fathers upon the children" may be thus explained, as for example we know to-day of the transmission of syphilis from the parents to the children, even before birth. Although I should like to elaborate some of these ideas, which of necessity are difficult, I must content myself with mere suggestions. I put them forward in the humble hope that their own inherent interest and importance may secure for them a consideration in this age of excitement and turmoil. In real social growth it has been well said that "science and religion are the outstanding cooperative agents."

Prominent thinkers have recently deplored the almost dormant intellectual life of many of the homes. The lack of thought in the home underlies the carelessness and want of a sense of responsibility so prevalent to-day. It is unfortunate that machinery has tended to lessen the interest of the worker in his work, as craftsmanship has become mere drudgery. This subject should receive most careful consideration at the hands of masters and men, as the capacity and intelligence of the individual manual worker is being unconsciously lowered, with corresponding danger to society.

Much in the past has been expected from education. But education has drifted along wrong lines, it has become mere

acquisition of knowledge, without due assimilation and application. The creative side of education is too often lacking. Again, there has been too much education of the individual, producing selfishness, and too little education of the community for the common weal. As H. G. Wells states in his "Salvaging of Civilisation," the "key to all our human disorder is organised education, comprehensive and universal." He also states that "education exists to subdue the individual for the good of the world and his own ultimate happiness." When people are educated on these lines they should be capable of adjusting the differences between capital and labour by the common-sense principle of "give and take," such as by co-partnership, profit-sharing, and wages boards, without resort to strikes. We hear too much nowadays of the duty of the State to the individual, but far too little of the duty of the individual to the State.

To return to the much-quoted phrase "improvement in the standard of living," it must include improvement in the standard of the mental qualities or intellect, not merely in physical well-being. This must be done by the mode of education just mentioned, and in that education the principles of animal biology, so fascinating to young and old, must be included. Further, we have to deplore the fact that the better elements of modern society are not reproducing at the same rate as the unfit. Some recent authors, such as Dean Inge and Austen Freeman, are very definite on this point. The former in a very recent review of the latter's book on "Social Decay and Regeneration," writes: "The ultimate factor of national decline is racial deterioration; and in modern societies this is very extensive and pernicious. Unfavourable variations are not eliminated, and there is a reversed natural selection in favour of the unfit."

In conclusion I would earnestly plead for the inculcation of the spirit of biology in *all* education, but it must be the spirit of the subject, not the mere dull facts in the form of dry bones. History also must be studied, so that the mistakes of the past need not be repeated. Karl Pearson, speaking to the British Association last year, said: "There is a conviction spreading in Germany that the war arose and the war was lost because a nation of professed thinkers had studied all sciences but had omitted to study aptly the science of man." He also states that "the future lies with the nation that most truly plans for the future, that studies most accurately the factors which will improve the racial qualities of future generations, either physically or mentally." Anthropology and sociology must be firmly based on biology. With a widespread knowledge of history, biology, and sociology, man should improve his environment and attain co-operation, peace, and higher ideals.

THE CLAIMS OF THE NATIVE QUESTION UPON SCIENTISTS.

By C. T. Loram, M.A., LL.B., Ph.D.,
Member of Native Affairs Commission.

Presidential Address to Section E, delivered July 13, 1921.

Recent happenings at Lovedale, Port Elizabeth, and Bulhoek have, or should have, demonstrated to the people of South Africa that in the adjustment to each other of the two races—the Native question, as we call it, and the European question, as I have seen it called in a Native newspaper—we have a situation as difficult as that in Ireland, and as vital to South Africa as was the Great War to the people of Europe. It will be remembered that in that conflict a situation of stalemate arose, when neither side appeared to be able to make progress. Then the help of the scientist was invoked, and with their energies stimulated by the great issues involved, the chemists, physicists, and engineers discovered, invented, or improved the poison gas, the bombs, the tanks, the submarines, and the other wonderful weapons of modern warfare. The Government and Parliament of this country, the officials and the general public, are faced with the most perplexing situation which has confronted South Africa, and, like the soldiers in the trenches, find it difficult to advance and impossible to retreat. The machinery for dealing with the Native question has become obsolete and ineffectual, and for too many years the very real difficulties of the position have caused us to do little or nothing, as if leaving the problem alone would make it any easier. If the war spirit were dominating us in this real but undramatic struggle for a fair and workable race adjustment, we should be aware of four great facts: First, that victory or success cannot be won without real sacrifice on the part of all sections of the community; secondly, that the moral and material support of the whole nation must be behind the undertaking; thirdly, that there must be unity of command with variety of attack; and finally, that the help of the scientist must be invoked. It is with the last of these points that I propose to deal in this paper, and it is with especial pleasure that I have seen that the President of the Association has set so good an example in bringing his wide knowledge and scientific methods to the study of our problem.

The general ignorance of the people on Native matters is appalling. Attendance at the debates in Parliament, discussions with municipal bodies and philanthropic Europeans, lectures to and meetings with Natives have convinced me that in attempting to attack this difficult problem we people of South Africa, like quack doctors, are prescribing for a complaint, while we are ignorant of both the disease and the general condition of the

patient. Like quacks we are proposing to make use of nostrums, and so we hear one section, generally Europeans, saying that if only we had *segregation* all would be well, while the other, generally Native, says that the *franchise* is the only remedy. The fact is that we are not ready to prescribe a remedy, because we have not sufficiently diagnosed the disease, and studied the treatment. Just as the war needed the chemist, the physicist, and the engineer, so the Native question needs the human-nature scientists, namely, the political scientist, the economist, the psychologist, and sociologist. It is not that we have not studied some Native matters in a scientific manner. The philologist has found, and is still finding, much in the languages of our Native peoples of interest and importance; the ethnologist has studied the varieties of the human race found in our country, but the majority of these studies have been made of the Native in his primitive or isolated state, when he has been little or not at all influenced by contact with white civilisation, and when he has not, therefore, become a problem to the European in the same sense in which the less romantic but much more troublesome educated or semi-educated Native is a problem. It is from the Native in contact with the European that the Native problem arises, and there is a great dearth of studies of the Native in this relationship. In the hope that I may be able to suggest some lines of investigation to officials, missionaries, and students of Native affairs, I propose to classify roughly the chief aspects in which the Native is a problem and to offer definite topics for monographic treatment by men and women of science. If some of these topics appear simple to this meeting let it be remembered that there are pack-bearers as well as field-marshals in the army of science.

Political Situations.

In connection with the government of the Native we have a situation which is difficult of classification. In the Cape Province any Native who has property to the value of seventy-five pounds, or who is in receipt of a wage of fifty pounds a year, and can write sufficiently to fill in the registration form, has the same right to the franchise as the European, and can sit as a member of the Provincial Parliament, though not of the Union House of Assembly. It is difficult to say how many Native voters there are in the Cape, but in 1919 the number of voters "other than European" was 33,139, which is about 20 per cent. of the total roll. In the other Provinces the Native has neither the Union nor Provincial franchise, and while the mass of the Natives do not want the vote particularly, the educated few protest strongly against this differential treatment.

In the Glen Grey District of the Cape Province, where since 1894 there has been a Council consisting of a European Magistrate, six nominated and six elected Native councillors, we have the first attempt to give the Natives a share in the management of local matters, such as education, roads, irrigation, the encouragement of agriculture, etc. The financial position in Glen Grey for the year 1918-1919 shows a revenue of £8,208 and an expenditure of

£7,804. The Glen Grey system was introduced into the Transkei in 1895, and here we have 18 District Councils managing local affairs and sending representatives to the Central Parliament—the Transkeian Territories General Council. This Council or Bhunga, which consists of the Chief Magistrate as chairman, eighteen Magistrates, and fifty-four Native members, has sittings which last a fortnight, during which time the getting and spending of a revenue of well over one hundred thousand pounds is considered. I have recently had an opportunity of watching the deliberations of the Bhunga, and, like most other observers of this Native Parliament, I have been much struck with the ability, sanity, and dignity of the members. In Western Pondoland there is a similar Council, though up to the present only three districts have accepted the system. The policy of the Government has been not to force the system on the people but to allow them to obtain it as soon as they are ready and express the desire. In the other Provinces the Natives have no share in their government, which duty is undertaken by European officials acting through Native chiefs and headmen. These chiefs and headmen are for the most part subsidised by Government, and possess limited jurisdiction in civil cases. In the urban areas the more progressive municipalities have instituted either nominated or elected boards of Natives to advise them on local matters.

It seems certain that participation by the Natives in the management of the affairs of the country is inadequate, except perhaps in the Cape Province, but before an extension is made it would be well if some students of political science would investigate some such problems as the following:—

1. The circumstances which led up to the granting of the franchise to the Cape Natives and the use they are making of the privilege.
2. Native opinion on the Glen Grey Council system and inferences therefrom for the improvement of the system.
3. What modifications of the Council system are necessary for its extension to districts such as Zululand and Basutoland, where the tribal system is entrenched.
4. Participation by Natives in urban areas in the management of their municipal affairs either by representation on the Town Council or otherwise.
5. A system of secret voting for Native illiterates.
6. A text-book on Civics for Native schools.
7. The treatment of Native history in European and Native schools.

Legal Relationships of Black and White.

It is freely conceded that justice and the authority of the law are corner stones in any system of government, so that it is imperative in South Africa that the Natives should respect the law and be ready to accept as signs of even-handed justice the decisions of the Courts. Ordinarily this is not difficult in the case of

Natives, who have always had a great respect for law, but recent happenings in our courts of law, where cases between Europeans and Natives are concerned, have shaken the Natives' belief in the impartiality of the white man's justice. Those interested may see several extraordinary cases referred to in an article in the "Christian Express" for June, 1921. It seems only too evident that the jury system cannot be relied upon in cases where Europeans are accused of criminal offences against Natives and *vice versa.* It has been suggested that trial by jury should be abolished in such cases or that a special panel of jurymen should be established, as is the case, I believe, in Rhodesia.

Another difficulty experienced by Natives is the not infrequent conflict between law and justice. To the Native mind it seems strange that a man should escape the consequences of illegal action merely through a legal quibble or the wiles of a clever lawyer.

Even if the law was administered fairly it remains to be decided if the Roman-Dutch Law of the Europeans is adequate to provide for justice among the much more primitive Bantu. In Natal there is a special codification of Native law and custom called the Natal Native Code, which determines legal proceedings among all the Natives in Natal except those especially exempted: in the Transkei the code is European, but the Magistrates are enjoined to take cognisance of Native custom: in the Ciskei and in the Transvaal and Free State the ordinary European law obtains.

Regarding the administration of justice in the courts of the Native chiefs and headmen complaints are not infrequent to the effect that the procedure is too often directed to the enrichment of the judge through court fees and fines for alleged contempt of court, than to the impartial incidence of justice.

If justice and law deserve the place which we have given to them as foundations for the government of the Natives it follows that we should spare no pains to improve the laws and legal proceedings relating to them. To do this we need the facts and not merely the popular generalisations on such points as these:—

1. A comparative study of the verdicts found and the sentences imposed in cases where Natives are charged with offences against Europeans with similar cases where Europeans are charged with offences against Natives.
2. In how many cases and for what offences have lashings been inflicted upon Natives? Group the results by Provinces and Judges.
3. The case for a public defendant as well as a public prosecutor for Native cases, especially those Natives arrested for breaches of the Borough bye-laws.
4. The Native lawyer and his cases and clients.
5. A study of a chief's or headman's court with stenographic reports of the proceedings and a statement showing the number and nature of the fines and fees paid.

6. A Native Code for the semi-civilised Native throughout South Africa.
7. A simplification of the existing European law in respect of land administration (surveying, transfers, etc.), inheritance and other legal proceedings in which Natives are concerned.

Economic Relationships.

The root causes of Native unrest in South Africa are agrarian and economic. Complaints regarding land, wages, prices, and taxation are the matters most frequently brought to the notice of the authorities, and this is not surprising since these matters affect all classes of Natives alike.

With regard to land the position is fairly well known. The Land Act of 1913 was an attempt at territorial segregation, and prevented the acquirement of land except with the consent of the Governor-General by a Native from a non-native or a non-native from a Native outside certain scheduled areas, and the acquirement of land by a non-native within the scheduled Native areas. Unfortunately the scheduled Native areas (which proposed to give 123,000,000 morgen to 660,000 rural Europeans, or 186 morgen per individual, and 18,250,000 morgen to 4,000,000 rural Natives, or 4.5 acres per individual) have never been finally determined, so that it has not been easy to proceed with the practical application of the measure, while the important legal decision in the case of Thomson and Stilwell versus Kama has made it doubtful if the Land Act is *intra vires* as far as the Cape Province is concerned. The Act is, of course, extraordinarily unpopular among Natives, and when meetings are held with Natives it is difficult to get them to discuss any subject but this.

As regards wages the economic position of the Natives has been affected by the rise and fall in the cost of living. No section of the people has been more hard hit by the high cost of living, both during and after the war, than the Natives, for almost all Natives except the most remote have to purchase their food and clothing at the kafir store where the Profiteering Act has been a dead letter. Increases in wages have been in no measure commensurate with the increased cost of living, so that the Native has had an undoubtedly just cause for complaint which would no doubt have expressed itself in a noisy, dramatic, but probably futile fashion had not the welcome drop in the cost of commodities taken place. For the most part we are ignorant of the wages received by Natives or their cost of living, but some helpful figures regarding town Natives have been published in the report of the Commission of Enquiry into the Port Elizabeth disturbances on October 23, 1920. In 1914 the minimum wage for unskilled Native labour was 2/6 per diem, and it remained at this figure until 1918. It then rose to 3/-, and in February, 1920, at the instigation of a Native Trades Union, it was raised to 3/6, and in September, 1920, as the result of further agitation, it was raised to 4/-. The percentage increase of the 1920 wage on that of 1914

was 60 per cent., but meantime the cost of living had increased to 105 per cent., so that the Natives were worse off by 40 per cent. Women were worse off than men, their wage having increased from 1/6 per diem in 1914 to 2/- in 1920. The wages of skilled Native workers had increased with that of their European fellow-workers by something like 120 per cent. The Commission estimated that the daily cost of foodstuffs for a single Native in 1920 was 2/7½ out of a wage of 4/-, thus leaving a man 1/4½ a day, or 33/- per month, for rent, clothing, etc. Rhodesia is the only other part of South Africa for which I have been able to obtain figures, and here an investigation undertaken by the Cost of Living Commission showed that in 1920 wages had increased by 13 per cent. on mines, 21 per cent. on farms, and 21 per cent. in domestic service, whereas the increase in the cost of ten articles generally purchased by Natives was 165 per cent.

With regard to taxation there has been little or no change since Union until this year, when the Transvaal imposed a poll tax on all male persons which has added 10/- per annum to the burden of the already most heavily taxed Native in the Union. The rates of taxation vary in the different Provinces, a practice which causes considerable dissatisfaction among Natives who do not understand the differences between urban, Provincial, and Union taxation, so that it seems certain that some uniform and equitable system must be devised. Before this can be done it would be well to have the assistance of some specialist in economics on the following and similar points:—

1. Communal and individual land tenure considered from an economic standpoint.
2. A soil survey and a sanitary survey of the areas set aside for Native occupation under the Land Act.
3. The economic status of Native farmers with special reference to the Native sugar planters of Natal.
4. A Land Bank for Natives.
5. The rates of wages and their relation to the cost of living for Natives in the following occupations: domestic servant, farm labourers, coal and gold miners, teachers, clergymen, interpreters.
6. Native professional and industrial organisations.
7. The operation of the colour bar in the European trades unions.
8. A consolidated measure of taxation for the Natives throughout the Union.
9. The apportionment of revenue derived from Natives among the several services rendered to them.

Psychological Considerations.

We are merely at the threshold of our knowledge with regard to the psychology of the Bantu, and the want of usable facts in this connection is hampering our legislation and administration at

every turn. Too often have we acted both in public and private relationships without knowing what was at the back of the black man's mind, with the result that we have had misunderstandings which have increased the Natives' suspicions of our actions and motives.

There is a lamentable supply of studies of race psychology, largely due to the difficulty in getting a sufficiently accurate knowledge of the language of the subject, and to the impossibility of estimating the changes which test material undergoes when translated into another language. The physiological differences between white and black which have been recently announced would seem to indicate that we are on the eve of an advance in our knowledge of the subject, but the psychologist has been so often baulked in his investigations on this line that he is more inclined to wish his brother scientist well in his researches and wait. Correlation between physical traits and mental characteristics has in the past been found to be wanting, and the variations in physiological characteristics between races have been almost always equalled by variations between different individuals of the same race, so that the psychologist feels that the relationship between mind and brain is still such a *terra incognita* that he prefers to proceed with his researches on the lines of dynamic psychology, and to gauge mentality by its reactions to objective situations, while waiting for the anatomist, physiologist, craniologist, and other workers on the substance of the brain to furnish him with their conclusions and suggestions.

From those who hold that the mind of the Native is as different from that of the European as is the colour of his skin, to those who see no difference between Native and European as far as mentality is concerned there are all shades of opinion. The best substantiated opinion, and it is little more than an opinion, is that differences between the mentality of Europeans and Natives are those of degree and not of kind, the peculiar characteristic of Native mentality being its immaturity. The more stimulating environment of the European has produced a less sluggish mind, less conservative, and more able to foretell the consequences of courses of action. Comparisons with the progressive Europeans who have come to this country, whose very presence here is evidence of a certain amount of enterprise and initiative on the part of themselves or their ancestors, is hardly fair to the Natives, but comparisons with the peasant classes in Europe or with the poor white class in this country, who have lived in a similar unstimulating environment would make us see fewer differences between Europeans and Natives than we do at present. Periodical outbreaks of animalness, both public and personal, among Europeans should remind us that we are not so far removed from our original nature as we would like to believe, while the many examples of prolonged and intensive study, of self-denial, and of willingness to suffer for a cause among the Natives prove that the Native can, when he thinks it worth his while, rise to the higher levels. The probability is that while most Europeans are superior to the average

Native in mentality there are certainly some Natives who are superior to the average European, and many who are superior to the lowest twenty-five per cent. of the European population. This fact proves the artificiality and impossibility of ultimate survival of a strict colour bar and is pregnant with trouble for us whites in the future.

If we are right in our surmise of the comparative mentality of the Natives, it follows that sublimation of original nature will be more difficult for Natives than for Europeans, and that to expect the same standard of personal morality, truthfulness, and gratitude (to select traits in which the black man is said to be wanting) is hardly fair, since the mass of the Native people, and certainly the servant class, from which we mostly make our inferences, is so little removed from a barbarian environment. The extraordinary fascination which the Old Testament has for Natives, evidenced so tragically at Bulhoek, should remind us that we are dealing with a people whose environment has produced a mental outlook which is many years behind our own. With the Native as with any primitive people, the emotions count more than the intellect, so that justice must be simpler, punishment more suitable, rewards more immediate, and sympathy more practical, if we are to deal psychologically with them.

The theory of the arrested mental development of Natives at puberty, to which the taking but irrational and misleading name of "mental saturation" has been given, and which the writer attempted to investigate in a former paper submitted to this Association, is being steadily refuted by the increasing number of Natives who take advanced, or at least post-puberty, courses in our educational institutions, but there seems a good deal of practical experience from this country to support McDougall's interesting theory that the inability to sublimate elementary passions and especially the sex instinct is responsible for a great deal of non-achievement on the part of primitive peoples. Here, again, restricted experiences and a narrow environment make it difficult to inculcate in our black people the ideals which lift a nation.

A vigorous attack on the much praised musical ability of the Bantu was made in the Report of the Superintendent of Education in Natal for 1919 by Mr. Percival R. Kirby, now Professor of Music in the University College, Johannesburg. Mr. Kirby is pessimistic about the teaching of music in the Native institutions of Natal, and feels that "the teachers are fighting against hereditary predispositions that are practically impossible to eradicate" for the so-called "natural harmony of the Zulu is no more natural to him than the European clothes which he wears, and it usually fits him as well as they do." Mr. Kirby says that up to the present he has never yet heard a set of even the simplest harmonies sung by a Zulu choir sufficiently well in tune to satisfy a cultured European musical ear. I have been hoping that some European or Native would comment on this iconoclastic criticism, but so far I have seen nothing in reply.

As suggestions for psychological research I would offer the following:—

1. The relative mentality of Europeans, Eur-Africans, and Natives as determined by tests not involving the use of language.
2. An adaptation of the Binet-Simon tests for Natives.
3. Relative ethical standards of Europeans and Natives as determined by means of tests involving their reactions to problems on ethical situations.
4. A study of a group of Eur-Africans living under Native conditions with a view to determining the effect of the European strain.
5. The musical ability of Natives.

Sociological Relationships.

Sociologically the Native is changing very rapidly under direct or indirect education by the European. His tribal customs are rapidly breaking down, and he is reorganising his social life on a new basis by adopting European habits of life. The adjustment is not easy and we find that it is at present the lower and more obvious aspects of our civilisation such as our food, our clothing, and our dwellings which are making the strongest appeal.

The beginnings of political and industrial groupings are clearly seen. The Native Teachers' Associations of the Cape and Natal have grown from mutual improvement societies to organisations for collective bargaining, and early this month the Natal Native Teachers' Union gave evidence of this new spirit by an attempted boycott of the Government's vacation course. The Industrial and Commercial Workers' Union of South Africa, which organised the recent strike at Port Elizabeth, pleads in the Native paper, *Umteteli wa Bantu*, of July 2 for reinforcements, saying, *inter alia*: "We should make up our minds to refuse to be dictated to by European trades unions. The right to sell our labour to the best market and to keep the market so reasonably high as to guarantee us not only a decent living but also to furnish the necessary means of life, is irrevocable. We alone can sacrifice it, alienate it, or give it away as a perpetual heritage to the European by surrendering to economic slavery. Workers, we have lost all in this country to the European, must we give up also the last and only right we can still claim to possess? God forbid. Come, let us reason together. Remember the 20th July at Capetown." In Johannesburg and other large cities there are small sectional unions. So far the conduct of these Unions has been characterised by much unwisdom, but there is no doubt that they are learning improved methods of action from white industrialists and that, if I am reading aright the signs of the times, before long the European employer will have to bargain collectively with the Natives.

However much we may regret the formation of these unions a study of the struggle between capital and labour in England in the nineteenth century must convince us that an amelioration of social conditions appears to be impossible without collectivism. "In all the movements [to an improved condition of the workers] we

have described, the spiritual stimulus, the initial drive, and the solid successes have been provided by voluntary associations. The State has not been the pioneer of Social Reform. Such a notion is the mirage of politicians. It has merely registered the insistent demands of voluntary effort or given legal recognition to accomplished facts. This is the distinctive note of English social development in the nineteenth century." (Fay, "Life and Labour in the Nineteenth Century.") The Natives will undoubtedly form their unions. Left alone they will probably act foolishly and wantonly. Is it not the part of wisdom to organise humanitarian groups of Europeans to guide them in the same way that the various philanthropic organisations in England, such as the Anti-Slavery Society, the Adult School Society, and similar groups assisted the working man?

In church matters we are in the midst of a strong movement towards separation. In the past there have been occasional secessions of Natives from European congregations, but the movement has spread considerably in recent years. The Native Affairs Department knows of 106 religious denominations under Native control, ranging from a flock of half a dozen with one pastor to a large organisation like the African Methodist Episcopal Church with a Negro bishop and nearly seventy congregations. The unfamiliarity of the names, "Natural Church of Ethiopia," "Christian Catholic Apostolic Church in Zion," "Pentecostal Holiness," "King of Salem" must not disguise from us the reality of their existence. The paper already quoted says: "We find that there are at least *one thousand* Natives within the municipal boundaries of Johannesburg who call themselves ministers, but who are unattached to any recognised church, and who live on the offerings of their respective flocks. Many of these self-ordained ministers are known to lead immoral lives, disgracing the cloth they wear and bringing Christianity into disrepute. They constitute a formidable hindrance to Native progress and the Native nation suffers obloquy because of them." This development of Ethiopianism deserves the sympathetic watchfulness of Europeans interested in Natives, for it is so easy for such religious bodies to become associated with political movements.

Of Native social clubs there is no end. Many have but short existences inasmuch as the correct management of the Society's funds appears to be beyond the capabilities of most of the Native treasurers. These clubs, too, find it almost impossible to refrain from politics, which has become the chief interest of educated Natives.

In the urban areas the conditions under which the Natives lived were very bad. In only two of the larger cities, Bloemfontein and Durban, had any adequate measures been taken to deal with the situation. In most towns the Natives had been placed in locations or allowed to squat upon the town lands, where they have built themselves shacks of wattle and daub, stones, and paraffin tins, which are not only an eyesore but are positive dangers to the morality and health of Europeans and Natives alike. In-

fectious disease is almost always prevalent in a more or less serious form. In the one location where an adequate attempt had been made to keep vital statistics the rate of infantile mortality in one year was 450 per 1,000, and of the births in that year more than half were of parents not united in wedlock by either European ceremony or Native custom. In most cases the Natives in the municipal locations were exploited for the purpose of municipal revenue. Thus of the 217 towns reporting to the Secretary of Native Affairs for the year 1916-1917, the last year for which figures are published, no fewer than 191 derived more revenue from Native sources than they expended on Native services. Sixty-four towns which received revenue from Natives varying from £2 to £806 are reported as spending "nil" on expenditure for Natives.

Among the questions awaiting investigation by the sociologist are the following:—

1. The origin, nature, and extent of the alleged anti-white propaganda in South Africa.
2. Native political organisations.
3. Ninevites and other secret societies among Natives.
4. Isitabane and organisations for vicious purposes.
5. Native child labour in towns.
6. Native night schools and their work.
7. The Native press with special reference to its vernacular articles.
8. The proprietary medicine trade among Natives.
9. The Native Church with special reference to separatist movements.
10. A survey of the racial, religious, housing and economic conditions of an urban Native location.

Conclusion.

I make no apology for having laid before you a series of questions rather than a set of answers, but I do so because those engaged in the administration of Native affairs want your help. Our neglect of a scientific treatment of the Native question has not only become a reproach but is now a positive danger, and if it is not yet time to cry "All hands to the pumps" it is time for those responsible for the formulation of a Native policy to seek the aid of the scientists. Of generalisations about the Native question we have perhaps enough, but of scientifically developed researches there is a great dearth. Our Section is, I believe, the youngest of the children of the Association, yet its work is vital to the existence of the European in South Africa. The press has always shown itself willing to help, bodies are not wanting to publish volumes on Native matters which by reason of their limited sale are not taken up in the ordinary course of business, the public is willing to be educated on this vital matter, and if, by reason of the position I hold in Native work, I can follow up a suggestion made at this meeting and constitute myself a clearing house for research on Native affairs, I shall be glad and honoured.

OBSERVATIONS AND PROPOSALS FOR THE STABILISATION OF MONEY VALUES.

By W. A. Macfadyen, M.A., LL.D.,

Professor of Philosophy, Transvaal University College, Pretoria.

Presidential Address to Section F, delivered July 13, 1921.

For some time it has become evident to students of economics that the most important and urgent question arising out of the economics of the Great War is that of the stabilisation of the values of money and the steadying of prices. Our experience of what is called inflation and deflation is worse than had ever been imagined. Both reach the private life of every individual in the State, and prove to be more calculated to produce distress and father discontent, disloyalty, and revolution than any grievances of a political or social kind of which modern society has had any experience. We have read in our textbooks of economics that rising prices and depreciating money penalise the wage-earners, and that falling prices and appreciating money burden industry and discourage enterprise, but the reality of the experience proves to be more serious than was represented. We have learned through bitter experience that fluctuation of values is a cause which is capable of shaking the fabric of modern civilisation to pieces. This corollary of war seems to have been neglected by all the Governments which have merely drifted in matters of economic policy since 1914. We shall show ourselves entirely incapable of learning from experience if we do not make the stabilisation of money values, and the preservation of such stability, the most fundamental interest of commercial, industrial, and democratic policies. The initiation of such a policy is beset with difficulties of a political or structural nature, the discussion or estimation of which hardly belongs to a Society of this kind. But the difficulties of a theoretical kind are no less real and do concern us here. I have come to the conclusion that the doctrine whereby the same material is both the standard of value and the medium of exchange prevents thinkers from seeing clearly what measures of reform are required in each sphere. It is a maxim of modern mechanics and invention that we never abandon integrity of function without failure of efficiency. The economy of making one device serve two purposes is a poor one and usually chimerical. To try to kill two birds with one stone is probably to lose them both. If then we recognise at once that the purposes of a medium of exchange and of a standard of value are different, we shall be clearing the ground for useful proposals. The virtue of a standard of value is to be stable, and that of a medium of exchange to be convenient, rapid, and frictionless. Paper currencies, duly secured and covered, fulfil the latter function admirably, but nothing could be so unsuitable as

a standard of value. Further, money is merely an instrument, and its amount, less or more, at a given moment is a matter of complete indifference, but that it should not change rapidly, or even perceptibly, in value proves to be one of the main interests of civilised society. It is because they seem to me relevant to this important question that I offer short studies or observations upon the economic disturbances caused by the late war. I shall call the subjects respectively: I. National bankruptcy; II. Economic disconformity; and III. Economic dependance.

I. National Bankruptcy.

In a recent book, "The Salvaging of Civilisation," H. G. Wells amplifies an idea suggested to him by his visit to Russia, namely, that European civilisation is suffering from a disease which might easily prove fatal and of which Bolshevism on the one side and militarism on the other are outstanding symptoms. As more or less relevant to the same idea, I beg to offer a few remarks upon aspects of the present world troubles which are new to economics. National bankruptcy must now be accepted as an economic fact; previously it was only a speculation. What is then this conception of national bankruptcy? In one view a nation identified with territorial limits is possessed of the hardest and most indestructible of assets and has always the reproductive powers of nature to fall back upon. Yet we shall see that there is a very real sense in which a nation can become bankrupt and practically lose the control for all purposes of credit and exchange of those same indestructible assets.

II. Economic Disconformity.

Secondly, the conception of an international standard of value and medium of exchange has recently become not only a thinkable but a necessary idea. The international exchanges which have hitherto served as bridges for commerce between different currency spheres have become to-day yawning gulfs which commerce shrinks from and finds itself unable to pass. Various schemes of a remedial nature have been brought forward such as a return to international barter and credits, international currency, and an international reserve superbanking system. It is impossible to understand, discuss, or form reasonable opinions upon any of these proposals without returning to first principles and trying to bring out the basal elements of these questions.

III. Economic Dependence.

Thirdly, the conception of economic independence, and its shadow economic dependence, from being largely of a speculative nature, has to us in South Africa become so far real and concrete as to have become the basis of a most important, and at first sight anomalous, decision in our national finance. The recent controversy with regard to the embargo on gold and the decision of the Government after full consideration to maintain the embargo has led Professor Edwin Cannon in the "Economist" to twit this country with having achieved an inconceivable paradox—the

greatest gold-producing country in the world has, he says, demonetised gold. This is, at first sight, true, and constitutes a real difficulty either to understand or to defend. The mordant criticism of Professor Cannon ignores the relativity of economic policy. What is best in a given case is governed by the environing conditions. It is common to classify nations as borrowing and lending nations, but we must now realise that this distinction represents a governing condition. The capital borrowed must be presumed to be for a vital interest; and all courses of conduct which would entail, or even render likely, its return become impolitic and impossible. Further payment of interest, as between country and country, can only be made by goods, and that means that a portion of the trade of a borrowing country is a tied trade in respect of which it has no freedom of will or judgment.

National Bankruptcy.

When in the second year of the war prices began to move much controversy arose as to the cause. Hitherto it had always been reasonable to suppose that when a general rise of prices took place this was caused by inflation of the currency. The principle of economy of hypothesis led to the preference of a single cause—like the manipulation or inflation of the currency—to the congruence or coincidence of many causes required to account for parallel movements of apparently unrelated products. There were, however, characteristics of the recent movement of prices which took it out of this category. The upward tendency of prices was obstinate and refractory to all expedients of treatment, and it was world-wide—in no sense confined to or even chiefly characteristic of the belligerent countries. Gradually it became recognised that some other than a purely currency influence was at work. The destruction of wealth caused by the war emerged as the only disturbing influence of sufficient force and extent to account for the phenomenon. The controversies on this point may be, I consider, regarded as closed by the speech of the Hon. B. H. Brand, C.M.G., as President of the Brussels Conference. This conception was indeed the basis of the weighty and important recommendations drafted by that Conference—since often more honoured in the breach than in the observance—against budgeting for a deficit and meeting deficits by loans. In view of their extreme importance to the theory of the economic basis of civilisation I give an abstract of their findings. The Conference found that the root cause of all the world's financial troubles was the destruction of capital caused by the war. This effect takes many forms:—

(1) The destruction of towns and villages in the areas devastated by war.
(2) The deterioration of railway systems, roads, and houses.
(3) The enforced sale of foreign securities to countries outside Europe.
(4) The huge external debts of the belligerent countries.
(5) The loss of working capital in the form of stocks of raw materials.

So intense were the demands of the Governments on the resources of their nations that they could not be met out of the annual product of the people, but had partly to be met by dissipating their capital. So great were they, too, that they could not be paid out of taxation or out of loans from the people's real savings. All Governments resorted to creating the purchasing power they needed by expanding, according to their necessities, either paper currency or banking credit, without any corresponding increase in real wealth. This form of so-called inflation is merely a method of concealed taxation by which a Government takes from its citizens their wealth, not by forcing them to pay over to the tax-gatherer, but by reducing its value. The more impoverished a country becomes the greater is the extent to which it is driven to trench upon its capital, and the further it is driven down this road to ruin.

So far-reaching are the effects of this form of so-called inflation that it is worth while to follow them out, as many of the evils are often attributed to other causes, and false diagnosis means wrong treatment.

(1) This form of inflation is the root cause of profiteering. As long as prices continue to rise, whoever makes or buys or holds goods at one price, and can, in a short time, sell them at a higher price, must profiteer.

(2) What the profiteer, whether capitalist or wage-earner, gains, is lost by all those living on fixed incomes or salaries, or on wages which have not increased with the increased cost of living. In this way the "new poor" are among the greatest sufferers through the war.

(3) By necessitating a constant readjustment between wages and prices—the "vicious spiral," as it has come to be called—causes constant strikes and labour unrest, thereby seriously impeding progress.

(4) By depreciating the currency it depreciates the exchanges. Thus imports cost more and prices are driven up.

(5) By increasing prices it increases Government and manufacturing expenditure. While revenue will ultimately increase in proportion to prices, expenditure tends to increase more quickly, causing constantly recurring deficits.

(6) By variation of prices and exchanges, legitimate trade and industry are replaced by speculation.

(7) Finally, these causes operate cumulatively and this form of so-called inflation disintegrates society and leads to chaos and anarchy. The Bolshevik plan of ruining western civilisation by forging unlimited quantities of each country's currency, if such paper could have been floated on the national markets, would have been certainly successful. For these reasons the Brussels International Financial Conference recognised that the first financial reform in Europe, on which all others depended, and the only means of avoiding ruin, was to check and to counteract this form of inflation. To this it only seems necessary to add that the community is an organic whole, not only as within the state, but within

the greater economic whole which has been created by the imports and exports of international trade. If production is reduced the standard of living is reduced; industry cannot be rendered unprofitable by limitation of output without first ruining industrialists. There is no other store or reservoir of wealth except the energy, skill and ability of the members of the community.

If this diagnosis of economic consequences of the Great War is correct, then we have it in the facts that besides inflation and deflation as explanations of price movements, there is a state of things conceivable which might be called, as distinct from production, destruction or demolition of wealth, and of this a chief symptom must be an extreme rise of prices. It seems important to recognise that such a rise of prices is of a different order to anything which can ordinarily be called inflation. A continued depreciation of the monetary standard is obvious upon any extended survey of the history of prices within the last 1,000 years. In the recent increase of industrial ventures in South Africa it is difficult to assign the share of assistance afforded by the protection of war isolation on the one side and that on the other by the stimulation of an inflated currency and the apparent creation of new wealth. At any rate, there can be no doubt that many economists consider that a certain measure of inflation is a beneficial rather than a destructive agency. Take for example the view of Gide—a reigning text-writer—(second edition, p. 229):—"The continued depreciation of the monetary standard is a phenomenon of great social importance, the effects of which must be regarded, after careful consideration, as beneficent. First of all the depreciation of money results ordinarily in a rise of prices. Now a rise of prices is a stimulus to production; it sustains the spirit of enterprise; it is favourable to an increase in wages; it acts like a tonic, and may be regarded as a symptom of economic vigour." I think it is evident that the phenomenon we have been studying is of a quite different order from this delightful and even exhilarating experience. I think we must distinguish between a rise of prices caused by an increase of the currency, and that caused by diminution or destruction of capital. The first may be beneficial—though even that is open to question—the latter cannot be beneficial, is certainly a symptom of economic disease, and, with its cumulation and progressive action as outlined above, may easily lead to a state of national bankruptcy. This conception seems to be new to economics and deserves consideration. It reveals a new danger in national life and gives a new significance to facts with which we have recently become familiar but only slowly have come to understand. If we regard the consequences of the so-called inflation as laid down by the Brussels Conference as stages in a development of bankruptcy, we realise that there are no European nations which do not exhibit some such characteristics. But the significance of a process is given by its end. Unfortunately, we have instances in Austria and Russia as described by Wells, which enable us to translate the general idea into concrete detail. When an individual becomes bankrupt an account is made of his assets

on the one side and of his liabilities on the other. A ratio is established at so much in the £, distribution of the assets takes place at such a figure, and the balance is written off as a loss to all concerned. In national insolvency there is no court to move; no estimation of the amount to be written off, but the same result is reached—annihilation of values—by an automatic process of rising prices. The State does not withdraw the money by taxation, but renders property worthless proportionately to the rise in prices. In Austria one crown instead of being worth ten pence is now worth about one-fifth of a penny; while in Russia roubles, which before the war would have been worth about £100,000, can now be bought as a speculation for £20. An Austrian teacher of whom I have heard retired on a pension of 2,000 crowns, with a purchasing power of £85, has now the impossible task of living on a purchasing power of £1 8s. The effect of such a state of things is that all foreign trade becomes impossible. The Austrian crown is depreciated to such a degree that it is virtually unrecognised abroad. Industry, so far as it depends on transport of raw material, is at a standstill. Fixed incomes and wages which have not managed to keep up with the cost of subsistence have become inadequate to support life. All credit is at an end, as creditors are ruined and refuse to lend. Modern economic civilisation, which is based upon production for exchange, has become impossible, and the only economic reality left standing is production for use, thus shelving or side-tracking the whole of the official, professional, and commercial classes. The economic bankruptcy of a nation then means reversion to an early or archaic type of civilisation—production for use only, and the sacrifice for a time of all the artistic and professional values of civilisation. Such a possibility affects every individual in the State, and ought to give him a direct and living interest in the policy of Government which may have such trenchant and far-reaching results.

Economic Disconformity.

The second large phenomenon of modern economics which appears to claim attention is the breakdown of the system of international exchanges. Although most social institutions and practices have beginnings which are unknown and work unconsciously and automatically, it is well to remember that society is instinct with purpose and it is always worth while, for purpose of interpretation and criticism, to treat such practices teleologically. From this point of view we may regard the system of international exchanges as an attempt to reduce national media of exchange to a common denominator in the bullion value of the respective currencies. For this purpose perfect and fluid permeation of gold as bullion is necessary. Freedom of import and export of the precious metal is of the very essence of the device. Only on such conditions was it possible to find an equation of exchange for the payment of the balances of international trade. The moment the freedom of flow was interrupted between country and country it was found that the integrity of the international basis had been eaten out by the substitution of notes and credit instruments locally valid, but

not internationally viable, for the only accepted international currency, bullion. The credit of national currencies was estimated in terms of the bullion cover held, and not in terms of the business transacted or to be transacted. The third term to which both sales and purchases were to be reduced split up into two terms—the currency credit of the selling and that of the purchasing nation, thus constituting a sort of economic *quaternio terminorum*, which instead of bridging extended the gulf between national currencies.

To understand the situation which eventuated between currency systems we may compare the banking system under separate and distinct reserves. If banks were to keep in cash all moneys deposited with them business would come to a standstill. If, again, banks were to lend all moneys deposited with them, panic would ensue, and within a short period collapse. Between these extremes lies the middle course—the finding of which means successful banking. The desirable system is that which enables banks, when necessary, to turn into cash the maximum of their assets with the minimum of general disturbance. Banks usually comply with these conditions by investing their deposits in overdrafts, bills, and short-time loans secured upon scrip. The proved disadvantage of this system of banking is that when it becomes desirable to strengthen their reserves banks call in overdrafts and short loans, and refuse to renew credit instruments, just when their debtors find it most difficult to repay them. Probably the latter even go to a competing bank. Thus the strengthening of one bank's reserve can only be accomplished at the expense of another bank. Practice has shown that in times of threatened crisis overdrafts and scrip loans cannot really be turned into liquid assets. Their withdrawal in times of active trade tends only to precipitate the crisis and causes a heavy destruction of values. Commercial paper without a discount market becomes again a lock-up of value till maturity. The evil effects of the strengthening of reserves by one bank at the expense of another was illustrated by American experience. In America there were frequently recurring crises culminating in the crisis of 1907, which very nearly led to a total collapse of credit. The narrow margin by which complete suspension had been missed led to a consideration of the situation and the eventual adoption of the Reserve Bank principle—a banker's bank, which gives to banks the same facilities which banks give to their customers.

The same characteristic of separate reserves was illustrated in South Africa last year. In one month one bank lost £1,300,000 of specie, while another gained £1,000,000. The loss to the first bank meant a reduction of that bank's metallic reserve of 50 per cent. The bank naturally curtailed its business and absolutely refused the most useful and legitimate business of a bank—the financing of produce in course of transit to market.

In both cases the same remedy has been devised, that of a central banking or central reserve system. Such a reserve bank is not a competitor of the commercial banks. It holds their reserves and only intervenes in times of crisis. Then it extends credit

liberally mainly by way of rediscounting sound bills. The knowledge that such bills can be turned into cash enables them to treat bills thus discounted as another reserve. It is this greater mobility of bank assets which makes the Central Reserve Banking system at once safer and more elastic than the system of decentralised reserves. Strengthening the reserve of one bank does not imply the weakening of other reserves. To enable such a Central Bank to fulfil these functions adequately it must have the sole right of note issue. Other credit instruments do not disturb the relation between cash and business. They each represent a transaction and expire when that transaction is finished, so they cannot possibly produce inflation. Notes, however, which pass into circulation and are re-issued when returned to the bank do add to the currency and sensibly disturb the balance between currency on the one side and wealth and business on the other. It seems sound, therefore, that they should be issued only on a backing of merchantable bills. It gives elasticity to the currency based on the changing demands of trade—expansion and contraction in accordance with the volume of the country's trade. The output of metallic currency is rigid and not necessarily related to the demands of trade. On the other hand the capricious, or the interested, issue of notes means inflation and the consequent raising of prices against the consumer. There is little doubt, therefore, that the policy of a Central Reserve Bank with powers of note issue subject to principle is both a sound and beneficial improvement to the banking system. It probably guarantees the maintenance of confidence and credit under circumstances of crisis when an internecine slaughter of values takes place under the circumstances of separate and independent reserves. It is probably a principle which might be introduced wherever there are competing banks of the commercial type, and operate as an independent but unmistakable function of government assuring the stability of values without interfering with the rapidity of exchange.

But a useful principle once discovered, and supported by successful practice, should be utilised to its fullest possibilities. It must accordingly be pointed out that the difficulties of international exchange are parallel to those of decentralised reserve banking: the absence of a common denominator, the estimation of sales and purchases in terms not of a common third measure, but in terms of separated and distinct reserves which have no necessary relation to each other, and are, in fact, often engaged in preying upon each other in a sort of elemental struggle for existence—all reproduce upon the stage of international finance the characteristics of decentralised and competitive banking. As they show the same diagnosis they are susceptible of the same cure. We may say, therefore, confidently that if there was an international reserve bank, with issue of an international currency, the difficulties of intercourse across the boundaries of currency systems would disappear. All other proposals, international barter, international credit, philanthropic proposals of one kind and another, fail to set up an automatic reflex system such as we enjoy in normal times within national limits.

If it be objected that such an International Reserve Bank is impracticable and Utopian, then it is proper to reply that it is for speculative criticism to form opinion, and much would be gained if we could obtain a clear idea of the measures which would relieve the present situation. But such a proposal is not so impracticable to-day as it might have been before the war. Is not this a function for a department of the League of Nations? The need is present, urgent, insistent, the beneficence unquestionable, and the effect would be increasingly and cumulatively remedial. If there is a case for simplifying the labour problem by starting a Labour Bureau of the League of Nations with a view to establishing a series of international subsistence minima, is not the case stronger for simplifying the whole system of exchange by establishing, what no one could object to, what all trade implies upon a lower national scale, a common measure of value. I am aware it is customary to say that the stabilisation of the exchanges depends upon the re-establishment of equilibrium in trade and finance. The equation is probably a reversible one, and it is at least true to say that the establishment of autonomous central banking would materially expedite the process. The shock to the international exchange on a bullion basis, which was given when free import and export of the precious metal was interfered with, has not yet been recovered from. The mutual want of confidence is indicated and measured by the dislocated exchanges. Nothing can repair the system but the re-establishment of confidence. We advocate a centralised banking system, as best calculated to establish and maintain such confidence.

Economic Dependence.

But not only is national interdependence evident in the economic sphere, it conditions our internal choice of policy. We have been led, as it seems to me, to appreciate in South Africa the reality and force of such a conception by our recent currency history. It will be remembered that in 1915 an embargo was laid on the export of gold by Proclamation, that on October 22, 1919, a Gold Conference was held in the Union Buildings which reported (i.) that it was not practicable to fix any definite data for the removal of the embargo; (ii.) that the best way of checking the disappearance of gold specie was to take gold out of circulation and replace it by fully covered certificates—temporarily inconvertible pending the restoration of the gold standard; (iii.) that the best way of establishing confidence and credit and avoiding financial crisis was the establishment of a Central Reserve Bank with suitable restrictions of cover and limitations of dividends. This report with its recommendations is severely criticised by Professor Edwin Cannon in the "Economic Journal," Vol. XXX, December, 1920. He points out that the real issue was whether it would be best for South Africa to keep its currency level with gold or level with the British paper pound. The Conference, he says, practically advised the latter course, and hence, as he puts it, the chief gold-producing country of the world has demonetised gold. There are minor criticisms to be passed on this mordant and trenchant attack, as Pro-

fessor Cannon is not quite fair to the banking proposals of the Committee, but what I think is of more general interest is to notice that the criticism ignores the extent to which South Africa was limited in its choice by the fact that she was a borrowing country. Besides the countless connections of business which cannot be broken at a moment's notice, South Africa has imported large quantities of capital from the London market and has to pay interest upon the same, by remitting a certain portion of its produce to the same market. To have elected to follow an independent line and make South African currency level with gold would have meant the re-export of all its borrowed capital. The temptation to have recalled such capital to London, taking advantage of the gold premium in transmision would have been too great to resist. The country would have been denuded of its necessary capital, development stopped, and a state of things indistinguishable from ruin produced. With this danger staring the Committee in the face can it be wondered at that they preferred the second alternative?

I have thus endeavoured to argue

(1) that the international export and investment of capital has woven the world into one financial system;

(2) that such an international system implies theoretically either a universal unit of account, or an international banking system;

(3) that the control of such a general standard of value so as to preserve an invariable ratio between goods and money is the most important of public and private interests. The slightest variation in such a ratio impedes and prejudices trade, while the larger and more rapid fluctuations in such an equation are capable of causing the dissolution of modern society itself.

I also commend to your consideration the view that while exchange, and the provision of a suitable medium of exchange may safely be left to the ingenuity of the commercial agencies which have already done so much for simplifying and expediting it, the question of the standard of value and its stabilisation is a matter which concerns every member of our civilisation, more nearly and poignantly than any other political or social question. I suggest that it should be placed under the care and supervision of some non-political officer or commission similar to the Auditor-General, directly responsible to representative institutions, but not functionally a part of the Government. Lastly and principally, as soon as possible, such non-political agency shall be internationalised and formed into a department of the League of Nations.

LAND CONNECTIONS BETWEEN THE OTHER CONTINENTS AND SOUTH AFRICA IN THE PAST.

By Alex. L. du Toit, D.Sc., F.G.S.,
Geologist to the Irrigation Department.

With Two Text Figures.

Public Evening Lecture, delivered July 15, 1921.

The subject chosen for this evening is by no means novel, being one that has repeatedly attracted the attention of biologists and geologists, but yet, on account of the vast conceptions demanded, has nevertheless maintained its fascinating character unimpaired.

The principle of splendid isolation appeals universally to mankind, and therefore it may be a little disconcerting at first to learn that in the dim past the African continent, geographically and biologically, was linked at times to the several other land-masses of the globe; that during a period to be measured by many millions of years there occurred revolutionary movements of land and sea involving the emergence and inundation of land-masses, the growth and destruction of mountain ranges, the pouring out of lava floods, amazing variations in climate, and marvellous evolution of animal and plant life.

Changes of Land and Sea.

That the lands are not fixed and unchanging was clearly appreciated in early history, but, conversely, that new land should have arisen out of the sea was an idea not so easy of credence. We have nevertheless as instances thereof the Himalayan ranges with their marine Tertiary strata sharply folded and elevated to extreme altitudes, while to take an example nearer home we possess the Devonian Bokkeveld series of the Cape with its dark slaty rocks carrying molluscan and crustacean fossils of undoubted marine affinities, such as can be dug out in the Hex River Valley or in the Bokkeveld thousands of feet above sea-level.

Evolution.

The study of fossil forms, known as palaeontology, has proved unquestionably the theory of evolution, according to which from the dawn of life upon this planet there has been a continuous chain of living forms, small variations from the type ultimately producing new species or genera. For any particular brief period life was more or less the same over the globe, but different as a whole from that of any other period; hence, when the fossils obtained from one series of beds in one part of the earth are found to be identical or very closely allied to those from another area, we may regard the two sets of strata as being of similar age.

The entire duration covered by fossil forms has for convenience been divided into epochs, each of which covers a period marked by the development of some important order of animal or plant life. For example, we have the Devonian characterised by the rise of the fishes, the Carboniferous of the Amphibia, the Permian of the Reptilia, the Triassic of the Dinosauria, the Jurassic of the ammonites and birds, the Cretaceous of the angiospermous plants, and the Tertiary of the mammals.

The time covered by each of these epochs is not determinable, but must run into millions of years. Although there was, as already stated, at any one time a similarity, often wonderful, in the life of the various parts of the globe, detailed study has shown that then, just as now, there existed differences of flora or fauna in particular regions, largely owing to the effects of environment or to migration.

It is well known that the marine faunas show less variation in this respect than land ones, the departure from the normal being most where the waters are confined, as for example in the Black Sea. Generally the migration of forms and their dispersal is not so much restricted in the ocean.

On the land, however, the spreading of animals and still more of plants is greatly hampered by barriers, physical, climatic or biological, with the result that the life in adjoining areas may come to differ very considerably.

Former Land Connections.

Particularly for the reason just mentioned must one avoid concluding that when the geological evidence points to the probable existence of a particular land-bridge in the past, some allied or even identical genera or species, extinct or living, ought to be found along its entire length.

Again to infer, because certain forms were able to migrate from one region to another, that a simultaneous interchange should have taken place between the two regions, is contrary to observation.

Where the two lands are close together the geological data may be sufficient to establish their former connection, but, where thousands of miles of ocean are separating them, the evidence demanded is mainly biological and the arguments have obviously to be weighty before geographical changes of such vast magnitude and revolutionary nature can be admitted.

It may happen, upon the breaking up of a continental mass into a series of islands, that of the forms thus isolated extinction overtakes certain of them through various natural causes, and at length they may come to be represented by but a few allied species in lands now parted by the ocean. For certain reasons it is commonly the more primitive forms that have thus become segregated.

It must frankly be admitted that land-connections between the continents have frequently been postulated upon very slender grounds and the strictures by Darwin and by Matthews in this

respect are not ill deserved. Taken item by item the resemblances displayed can often be accounted for in some other manner or the arguments dismissed as inconclusive, but in the case under discussion the resemblances are so numerous and their explanation so difficult in any other way, as to force one to the conclusion that the various land-masses in the southern hemisphere were interlinked in the past. This date was, of course, very far back in the history of the earth, during the Carboniferous and Permian epochs in fact.

Opinions upon such former Land Connections.

In 1870 G. W. Stow, to whom the science of geology in South Africa owes so much, advanced views of this nature when comparing the fossiliferous Uitenhage beds with their seeming equivalents in India.

The same year Huxley admitted the strength of the arguments in favour of a union of Ethiopia and India during the middle of the Tertiary epoch.

Observing the distribution of the living and extinct *Lemurs*, P. L. Sclater, about 1875, not only suggested the linking of Madagascar to Africa and to India during the Tertiary, but gave this tract of land the name "Lemuria."

In 1875 W. Blanford pointed out that Madagascar, the Seychelles, Mauritius, etc., could be interpreted as a partially submerged mountain chain; that the Indian fauna is close to that of N. Africa, that there is also a fauna related to that of tropical and S. Africa or to Madagascar, e.g., the scaly anteaters; that the Indian badger is closely related to the Cape ratel; that the land Mollusca include many kindred forms, and more particularly that the fossil reptiles and plants of the two continents are closely allied.

It was the last-mentioned aspect that commended itself to the eminent geologist Suess, who termed this hypothetical but much more ancient continental connection "Gondwanaland," and extended it across the Atlantic to Brazil. Von Ihering called the western bridge "Arch-Hellenis," and conjectured it as having extended from Brazil to Central Africa. Engler, the great botanist, concluded that the floral relationships observed could best be explained by a tract of land or a chain of large islands between Northern Brazil and the Bight of Biafra. Scharff, the zoologist placed the connecting land to the south of the group of islands north of the equator. Other scientists again studied the life of Patagonia, Australia, and Antarctica, and thereby were able to point out various interesting relationships.

Faunal Survivals.

There are quite a number of orders and families practically confined to the southern hemisphere, for example the blind snakes and the geckos, while the freshwater decapod Crustacea of the southern half of the globe are distinct from those of the northern.

It is curious to observe in illustration of a previous statement obscure primitive types still surviving in these southern lands, for instance the fresh-water fishes *Ceratodus* in Australia, *Polypterus*

and *Protopterus* in Africa, and *Lepidosiren* in Brazil, while living or recently extinct large birds of the *Struthio* type characterise the above-mentioned countries, and in addition Madagascar and New Zealand. These ancient lands have formed for such long-pedigreed forms what Suess has aptly termed asylums.

Recently new links have been obtained. *Phreatoicus* is a minute shrimp-like crustacean intermediate between the Isopoda and the Amphipoda. It lives in tarns and, first found in Tasmania and Victoria, was not so long since discovered on Table Mountain and Sneeuw Kop in the Western Province.

The *Phreodrilidae* are worms up to an inch in length intermediate between the terrestrial and the aquatic Oligochaeta, and are found in pools on mountain peaks in Australia, Tasmania, New Zealand, Kerguelen Island, South Africa, Falkland Islands, and Patagonia. They are descendants of an old cold climate stock, and clearly could not have crossed the oceans. There is almost a similar distribution in the case of the remarkable *Peripatus*.

The Northern and Southern Floras of the Carboniferous Period.

It is, however, when we come to consider the life of the past and compare the geology of the regions concerned that the evidence piles up in a rapid and most convincing manner.

To do so it is necessary to go back to the Carboniferous epoch, to the time when in the northern hemisphere the forming of coal-seams was actively in progress. Such coals are believed to have been accumulated on vast flats comparable in some respects with the Great Dismal Swamp of Virginia, the climate being moist and probably temperate.

The vegetation at that period included many strange forms, mostly vascular cryptogams, predominantly Equisetales, Lycopodia, Pteridosperms and Ferns—a rather monotonous assemblage all the same.

This will be referred to as the "Northern Flora."

In the southern hemisphere and in India, on the other hand, the climatic conditions became such as to lead ultimately to the development of extensive snow and ice caps at a number of separate centres. Continued accumulation of snow caused huge ice-sheets to spread outwards and move across the lower ground, just as in the cases of Greenland and Antarctica at the present day.

At the period of maximum glaciation no small proportion of the southern hemisphere must have lain buried beneath a mantle of ice thousands of feet in thickness, just as at a very much later date was the case in the northern hemisphere during the Great Ice Age; the details will be discussed shortly.

At the same time, and according to some palaeobotanists as a consequence of the general lowering of temperature, a flora made its appearance quite distinct from that of the northern hemisphere, known as the "Southern" or "*Glossopteris Flora*," from the name of the tongue-shaped frond of its commonest form; this vegetation gave rise to the coal-seams of Gondwanaland.

Furthermore, there appeared in this half of the world, but principally in South Africa, a wonderful assemblage of reptilian forms, the morphological study of which has so brilliantly confirmed the doctrine of Evolution.

The Glaciation of Gondwanaland.

Before describing this amazing glacial episode of the Carboniferous epoch, just a few words are needed to explain why geologists have both formulated and accepted views demanding such a radical change of climate over so vast a territory.

Glaciers in moving down to lower levels carry with them rock débris either resting upon their surfaces or embedded in the ice itself. The inclusions in the ice-foot, pressed down upon the rock floor over which the ice is moving, polishes and scratches the latter, hence the peculiar striated surfaces characteristic of areas formerly over-ridden by ice-sheets. Upon the melting of the latter the clay, sand and boulders are deposited upon the floor, this material being termed "moraine" or "till."

It is unbedded, possesses a clayey matrix, contains striated and facetted boulders which are sometimes many feet in diameter and are of various types of rock such as the ice has moved across; occasionally they may have been transported for hundreds of miles.

About half a century ago formations were observed in India, South Africa, and Australia that pointed to glaciation, and, though the opinions then expressed for quite a while failed to receive due recognition, subsequent work has proved to the full with a wealth of detail the correctness of this original interpretation. It will be of no small interest for you to realise that the morainic character of this deposit was recognised by Sutherland and by Griesbach in these early days and that one of the critical localities cited is near the Umgeni Bridge only a few miles north of Durban. The floor is a finely grooved surface of hard white sandstone, while the overlying morainic deposit, now consolidated by age and pressure, is the peculiar green-blue rock with pebbles and boulders used for macadamising the streets of Durban.

The identical formation was later on observed by Dunn in the Cape and its true nature recognised by him; from its occurrence, crossing the Dwyka River near Prince Albert, it received the name of the "Dwyka Conglomerate," a term familiar to geologists the world over. Since then it has been traced over a great area, and either covers or else underlies nearly two-thirds of the Union, and, while variable in thickness, exceeds a thousand feet in depth over wide stretches.

Movement of the Ice in South Africa.

Wherever the conglomerate has been stripped by erosion from the floor the latter is found to be uneven but striated; the direction of the groovings reveals in addition the course of the ice movement, while the nature of the boulders gives a clue as to the source of the ice itself.

With these as our guide it is possible to attempt the reconstruction of the past, and it has been made out that the principal ice-

cap had its centre in the Transvaal, whence it radiated outwards, moving westwards into S.W. Africa, south-westwards into the Cape, and south-eastwards into Zululand. Natal itself was invaded by a separate sheet having its origin out over what is now the Indian Ocean, and apparently being a portion of the body that entered Southern Madagascar, where this formation has also been recognised. In the south the several ice-bodies coalesced, passed into water, and floated, no doubt after the manner of the Great Barrier Ice of Antarctica.

The Ice Fields of Gondwanaland.

The elucidation of the behaviour of this vast ice-field with a thickness of several thousands of feet is one of the triumphs of geological deduction, and the discovery is all the more remarkable inasmuch as it implies that the northern boundary of the body would have been situated about the twenty-first parallel, so that the ice-field would have lain in what is now the temperate girdle of the earth, far removed indeed from our present South Pole.

The causes of this phenomenal refrigeration, the reality of which is admitted by all authorities as indisputable, have so far defied solution, and the problem has remained one of the great puzzles of science, as well as one of the most fascinating.

Turning our attention to South-Western Brazil and the Northern Argentine it is remarkable to find a glacial conglomerate of the same age as the Dwyka, derived as far as can be judged from an ice-sheet having its origin out in the present Atlantic, off the coast of Uruguay; to the north-west lay the ocean which it entered. In the Falkland Islands the geology is identical with that of the Cape, but the centre of origin of the ice is unknown.

During the Carboniferous epoch Peninsular India was heavily iced, the sheet moving northwards to discharge its débris into an ocean where the Indus now flows. In Australia we find similar occurrences, proving that a great ice-body radiated from some centre to the south of that continent, moved northwards across land in Victoria and South Australia, and terminated in an ocean to the west, north, and east along a line some distance within the present coast. Tasmania was also over-ridden, and possibly New Zealand. South Victoria Land in the Antarctic certainly belonged to this continent, but no data have yet been obtained to prove whether it suffered glaciation, though probably it did.

Although the several areas referred to formed parts of the Carboniferous continent, only certain sections of each actually experienced this glaciation. The northern region in Australia escaped, most of Madagascar, all in Africa between latitudes 21° S. and about 15° N., and in South America the territory from Paraguay to Venezuela.

Gondwanaland.

The foregoing represents Gondwanaland as generally conceived, and, although its southern limits are problematical, it is obvious that in size it would have rivalled Eurasia. With a restoration

on these lines the geologist is confronted by several difficulties, the most formidable of which—one that has hitherto been insuperable—arising out of the extraordinary location of the ice-centres, namely, in the temperate girdle, and their peculiar attitudes to one another.

For explanation I am advancing in all seriousness the view, revolutionary and heretical as it will appear to orthodox geologists, that Gondwanaland was a much smaller continent than as usually conceived, that its centre lay somewhat further to the south, that the Carboniferous ice-sheet was an almost continuous mass, and that *the land fragments still preserved represent portions of the ancient continent forcibly torn apart, subsequently modified in outline by erosion, deposition, etc., and now separated by vast stretches of ocean.*

The customary view is that these stretches of water have developed as areas of down-warping, the main outlines of the lands having been determined by extensive faults and modified by subsequent marine erosion.

That the continents might have originated by the actual tearing apart of one or more much larger masses is no new doctrine. Although generally dismissed as fantastic, it has been very ably championed recently by Wegener, and, when the hypothesis is studied in detail, the evidence in its support is found to mount up so remarkably as to become almost overwhelming; only a few of the arguments in its favour can be presented, however.

It will forthwith be realised that by thus supposing the several units to have been spaced much closer together in the past, the numerous remarkable lithological and palaeontological resemblances between them become more explicable, while the difficulties that beset migration become much reduced. Moreover, the areas known to have been capped by ice become roughly grouped around the South Pole, not far from, if not well within, the present northern limits of drift-ice, and a serious stumbling block to the interpretation of the Carboniferous Ice Age is thereby removed. (See Fig. 1.)

This hypothesis indeed becomes the key to the understanding of the past, and during the rest of this discourse it is this reduced and modified conception of Gondwanaland that will be referred to.

The Deposits of Gondwanaland.

With the melting of the ice-sheets the borders of the lands were submerged and a series of strata laid down varying in places from marine through estuarine and lacustrine to continental types over very considerable portions of the area and to a thickness of many thousands of feet occasionally.

During this lengthy period the geographical and climatic conditions changed repeatedly over the entire continent, as would be expected. In South Africa land prevailed in the north of the Union, and the muds and sands washed down therefrom collected in an ever-deepening trough in the south. This latter probably formed an immense extent of flats, now flooded, now dried up or dotted with lakes and pans; entombed in the silts thus laid down over them are the fossil remains of animal and plant life. This

important deposit is appropriately known as the Karroo Formation or System.

Fig. 1.

Hypothetical restoration of Gondwanaland at the close of the Carboniferous Epoch. The ruled areas are those known to have been covered by ice, the arrows indicating the direction of movement of the latter.

Rise and Spread of the Glossopteris Flora.

In the other sections of the Continent rather similar conditions held sway, and, strikingly, the deposits in each of the areas are characterised by the presence of the Glossopteris flora. This is even the case with Antarctica, for fronds of *Glossopteris* and pieces of fossil coniferous wood have been discovered in the Beacon Sandstone of South Victoria Land, now a treeless frozen territory. The find is, however, no more extraordinary than that of plants proving a temperate and even an approach to a sub-tropical climate during the Middle Tertiary in regions of quite as high a latitude, namely, Spitzbergen and Greenland.

The origin of the southern flora is uncertain, but what may possibly be its earliest appearance is indicated by the recent discovery by Mr. T. N. Leslie at Vereeniging of fronds of the important allied genus *Gangamopteris* below the glacial moraine, so that here the flora must have been at least contemporaneous with glacial conditions.

Some botanists have ascribed the wide development of this flora to an ability to withstand the rigorous climate, whereas the northern Carboniferous plants were not so fitted. It is hence particularly suggestive to find that in North-Western Argentine and Southern Brazil there is an actual intermingling of the two floras, the northern forms probably having been derived from North America. This incursion makes its appearance just after the vanishing of the ice, and is also found in South Africa, but at a slightly later date; in India immigration of exotic forms was slight, and in Australia practically absent.

We are fortunately in the position to decide the relative dates of the invasions on the two sides of the Atlantic by the fact that there is a very peculiar thin zone of carbonaceous pyritic shales common to the Cape and S.W. Africa and to Brazil and Uruguay in which are preserved remains of the primitive free-swimming little *Mesosaurus*, the earliest known reptile of the southern hemisphere. This is one of the many extraordinary likenesses in the strata deposited at the same time in areas now a few thousand miles apart.

There is so striking a uniformity in the indigenous floral assemblages of the several regions referred to as to compel us to the recognition of the latter as parts of one ancient continent; this applies not only to one particular geological stage, but to the whole time-interval during which Gondwanaland existed, namely, from the Upper Carboniferous to the Jurassic. There is a community of genera and of species testifying to a lack of hindrances to floral migration in the south precisely as was the case in the north with the northern flora throughout the identical period.

At one time, in the late Permian, *Glossopteris* itself spread outside the recognised borders of Gondwanaland and actually reached Northern Russia, though failing to establish a secure foothold. The subsequent developments of the southern flora show on the contrary that an invasion by northern forms took place, connection with Europe becoming freer, and *Glossopteris*, although lingering on into the Upper Triassic in Natal and Indo-China, was extinguished by the incoming of hordes of cycads, conifers, and ferns. In this manner the plant life of the southern hemisphere came to approximate very closely to that of the northern, and the uniformity thus established in Rhaetic (late Triassic) times persisted all over the globe until late in the Jurassic.

Permian and Triassic Vertebrate Life.

The record of the vertebrate life is both ample and corroborative. Probably few persons are aware of the numerous and marvellous finds that have been made in the Karroo Beds since the days of Bain and Atherstone, discoveries that are not only helping to fill up the many gaps in the palaeontological record, but are throwing much light upon the conditions that prevailed.

The Pareiasaurians, for example, were heavily built reptiles with a length of 8 or 9 feet, possessing broad flattened skulls, jaws bordered by uniform, serrated teeth, powerful limbs and claws which indicate digging abilities. Their skeletons have generally

been found back uppermost with all the bones in position, as though the animals had died where they were found and were covered up rapidly either by mud or dust.

Large quadrupeds first make their appearance in the south-western corner of the Karroo, and shortly afterwards, during Lower Beaufort times we find many strange forms such as *Pareiasaurus*, *Tapinocephalus*, *Titanosuchus*, and *Dicynodon* over a wider area in the Cape, but not in the north or north-east. Furthermore this early fauna possesses well-marked affinities with the corresponding Permian Reptilia and Amphibia of North America, a resemblance that vanishes later. Broom believes that, while the two assemblages sprang from a common stock, the American offshoot remained nearer the centre of their evolution.

Migration of the Vertebrates.

The route taken by this early Karroo fauna was probably via the Northern Argentine and Southern Brazil, and, although these forms have not yet been discovered in those regions, this can be explained by a known stratigraphical break in the succession there, during which no sediments were laid down, and consequently no fossil remains preserved.

Suggestively, too, these precursors of the Middle Karroo fauna have left no representatives elsewhere in Gondwanaland, but a little later, near the close of the Middle Permian, we find their descendants not only in the Orange Free State and Natal, but even in Madagascar and India, and, though failing to reach Australia, they succeeded in penetrating into Northern Russia, where on the banks of the Dwina their remains were discovered by Amalitzky associated with *Glossopteris*. Isolated on what seems to have formed a peninsula in the Permian seas, the fauna became somewhat specialised. Since the vertebrates of this age included herbivorous as well as carnivorous forms, for example the *Pareiasauria*, one may be permitted to speculate that with the spreading of the Glossopteris Flora—a more or less xerophytic vegetation, be it noted—into this northern area, the animals followed in search of pasture.

During the Permian and Triassic, a period certainly covering some millions of years, vertebrate evolution was particularly active in South Africa, and among the Reptilia the advances were generally, but not always, towards the acquirement of mammalian characters. The Middle Triassic was marked by the rise of the highest forms of the *Theriodontia*, of which one South African genus has been discovered in Brazil and an allied one in India.

During the Upper Triassic, however, Gondwanaland, as already stated, certainly became linked to Europe, and, just as this union is reflected in the composition of the flora, so here again we find an influx of northern types of Reptilia, Amphibia, and fresh-water fishes, chief among which are the *Dinosauria*, those strange, long-necked quadrupeds that took to sitting or even walking in a semi-erect position with the long tail as a support. It is curious to discover that the South African genera and species—found not

only in the Cape, but in the Transvaal and Southern Rhodesia as well—are most closely allied to forms in Germany, where comparable climatic conditions prevailed, while the influence of South Africa seems to be recorded in the strange desert fauna of the equivalent Elgin Sandstone of Scotland. Certain European genera reached Brazil, India, and Australia as well as South Africa.

Desert Conditions during the Triassic.

The climate in South Africa with one marked pluvial interruption had for long been on the border-line of semi-aridity, as indicated by curious maroon and green shales and mudstones, calcareous nodules and peculiar sandstones, so that it is not surprising to find arid conditions having set in over a very large region at the extreme close of the Triassic.

This desiccation was most acute in Rhodesia, a territory which, like all desert regions of the present day, is situated within the sub-tropical belt; even in parts of Europe at this period similar conditions held sway. An even mantle of very fine wind-worn sand became spread over the face of the land, while in the region more to the south the level of the ground was gradually raised by fine dust blown thither by the prevailing north-westerly wind. This deposit, in places hundreds of feet in thickness, is in certain lithological characters rather like the loess of China, and is white, cream, or pink in colour, known in Rhodesia as the Forest Sandstone, in the Transvaal as the Bushveld Sandstone, and in the Cape and Natal as the Cave Sandstone. Its scanty fauna includes forms with long slender limbs, a peculiarity of animals inhabiting steppes, while signs of vegetation are wanting.

Conditions such as these existed simultaneously in Southern Brazil and probably in North-Eastern Rhodesia and the Congo Basin, while there are indications to that effect in India as well, but not in Eastern Australia; of those of Western Australia there is no evidence as yet.

Volcanicity at the close of the Triassic and its Results.

Such were the environmental conditions when simultaneously South Africa, Central South America, and India were overtaken by violent volcanic eruptions, at first through pipes and later from fissures, while the process of deposition was stopped by the pouring out of vast quantities of basaltic lavas. Some of the molten matter, unable to reach the surface, burst in various directions through the basement strata and solidified, forming innumerable sheets of dolerite. At the same time great movements of the earth's crust were initiated and the breaking up of Gondwanaland began.

In South Africa the lavas not only formed a huge pile thousands of feet in thickness over the Basutoland region, but overwhelmed extensive tracts in the Central and Northern Transvaal, Southern Rhodesia, the Zambezi Valley, Nyasaland, and two areas in S.W. Africa. In Brazil, Uruguay, and Paraguay the basalts

cover an enormous territory, while their Indian equivalents are represented in the Rajmahal Hills, near Calcutta.

Both Tasmania and South Victoria Land were extensively invaded by dolerites belonging to the intrusive phase, but no basalts have been preserved.

These tremendous outbursts at the beginning of the Jurassic epoch interrupted the life history of Gondwanaland very considerably; sedimentation was restricted, and only along the now submerging coastlines were the remains of plants and animals preserved in estuarine or marine beds. In both South Africa and South America the gap is most extensive; in Madagascar the plants and the dinosaurian remains are of European genera, but it is really not until the Cretaceous epoch that the history of Gondwanaland becomes clearer.

Crustal Movements.

The breaking up of the ancient continent with redistribution of the land and water formed a part of an ordered scheme of crustal movements upon the earth, the reasons for which will have to be briefly discussed.

Examination of the past history of the globe has shown that there has been throughout the various geological epochs a fairly regular series of operations around the margins of the continents, namely 1) deposition of sediment in the ocean, (2) depression of its floor, (3) compression and upheaval of the latter, (4) igneous effusion and injection—the cycle being subject, of course, to certain local modifications.

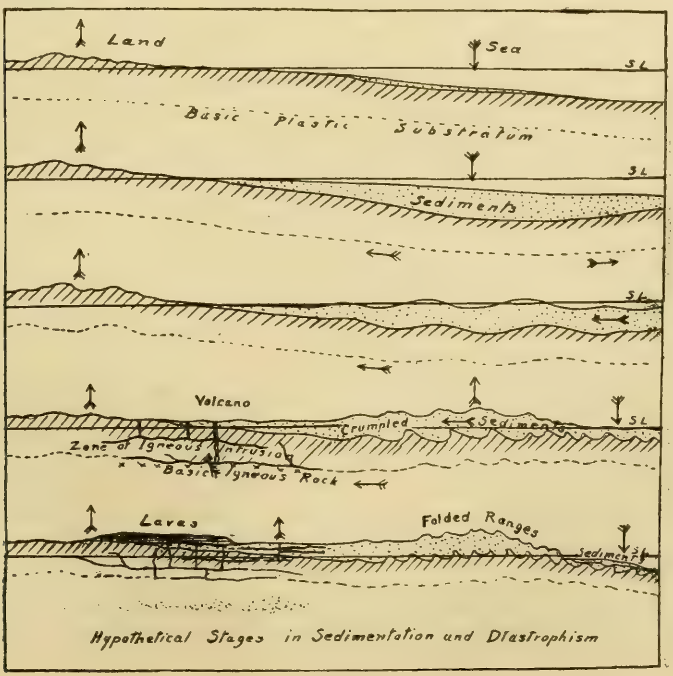


Fig. 2.

Several independent lines of reasoning lead to the opinion, generally accepted, that the earth possesses a solid shell or crust and a fairly solid heated core, but that the transitional zone is plastic or at least semi-plastic in its nature. The depth down to this substratum is uncertain, but probably ranges between about fifteen and fifty miles, and, if the crust be excessively loaded at any point, it will tend to sink down at that spot, while at the same time some of the substratum becomes forced out from beneath the weighted area and raises the crust adjoining thereto.

It is a truism that the land is gradually being worn down and its waste deposited in the ocean; the land therefore grows lighter, while on the contrary the ocean floor adjoining becomes heavier The balance between the land and the oceanic areas being thus upset, the former tends to rise and the floor of the latter to sink.

Once established, this differential movement continues, and would go on indefinitely, widening its sphere of operation, were it not for the behaviour of the sub-stratum in being squeezed out from below the part of the crust supporting the gradually subsiding ocean floor and making its way into the base of the rising land-mass. Such conditions are quite unstable; the crust of the earth is usually under considerable lateral pressure and is resting not on a fixed foundation, but on a now slowly creeping sub-stratum. The result is that the land portion becomes compressed into a series of more or less parallel folds and elevated as mountain ranges, while the sub-stratum beneath, being a potential eruptive magma, liquifies with relief of pressure and bursts upwards through the strata, either pouring out at the surface in the form of lava or remaining below ground and consolidating as an intrusive rock. (See Fig 2.)

Earth Foldings Affecting Gondwanaland.

Now this is precisely what has happened in South Africa. The land lay in the north of the Union, and, in the southern part of the Cape, sediments had accumulated to a depth of about four *miles* during the interval from the Devonian to the Triassic. The deformation became so great finally that the crust collapsed and was thrown into a multitude of sharp folds, huge thicknesses of even such hard rocks as quartzite being puckered up in concertina fashion and the arches being often overturned; in this manner the Southern Cape Ranges striking east and west originated. The area inland, beyond the belt of folding, was flooded with basaltic lava-flows, while the strata beneath became riddled by sheets and dykes of dolerite; to the south subsidences took place and the waters of the ocean proceeded to make inroads upon the newly rising lands.

In this cataclysmic cycle South Africa did not stand alone. The belt of collapse extended westwards, passed through the Argentine with a trend more to the north-west, and continued into Northern Chili and Bolivia. The pressure there folded strata identical lithologically and palaeontologically with those of the Cape and left untilted the *Glossopteris*-bearing beds of Uruguay and Southern Brazil, just as in the Great Karroo; further these deposits

of Gondwanaland here also became flooded with basalt and injected with dolerite. The equivalent Devonian to Permian strata in the Falkland Islands also suffered compression in the same way. In the opposite direction the Cape folds are lost beneath the waters of the Indian Ocean, but may have extended to the south of Tasmania.

These compressive earth movements must have already been in progress before the close of the Triassic, but seem to have attained their maxima in the Jurassic. By this time it is not unlikely that the African section of Godwanaland had parted from the Australian and Antarctic portions, a view that receives reasonable support from palaeontological evidence; Africa, India, and South America were, however, still united at this time.

We are now entering a stage of this problem where any views are of necessity largely speculative and where the fullest use has to be made of all the information obtainable from the patches of Mesozoic strata that fringe the present continents.

Evidence from Marine Marginal Deposits.

It is known that the Carboniferous and Permian ocean occupied extra-Peninsular India, extended through Burmah and Malaysia, and covered the north-western shores of Australia, where a fauna of the Indian type occurs. Into this ocean the Carboniferous land-ice had moved with a general northerly direction, both in Western Australia and in Northern Peninsular India, We can surmise that the ocean originally formed a gulf between the two areas which started to develop either in the Triassic or in the Jurassic, and to extend itself west-south-westwards into the heart of the ancient continent. By the very beginning of the Cretaceous it had invaded the southern end of Africa, but certainly did not reach the Argentine until the end of that epoch; not improbably it progressed by following troughs in the belt of earlier and now extinct, nearly east-west foldings. From evidence to be presented later this new-growing southern ocean did not send an arm up the Atlantic to sever the Afro-American mass till a later period.

The marine Jurassic strata of Western India, East Africa, and Western Madagascar similarly point to the separation of India as having begun from the north and that the trough between them, actually initiated in the Triassic, gradually lengthened in a south-south-westerly direction along the line of the present Mozambique Channel. Nevertheless there is no evidence that Madagascar was cut off from Africa during the Jurassic epoch; such was left until the time of the great marine transgression that affected such a vast proportion of the globe in the Cretaceous. This ocean largely followed up the inroads that had been made in Jurassic times, and, according to the hypothesis here presented, took occupation of the spaces formed by the gradual drawing apart of the several sections of Gondwanaland.

The Lower Cretaceous faunas of Western Australia, Assam, Western Peninsular India, Eastern Madagascar, Portuguese East Africa, and South Africa are closely allied, but the equivalent

fauna on the north and west of Peninsular India has on the contrary a marked European facies. These contrasting faunas indicate that Madagascar was still joined to India and must have formed a peninsula at one point at least quite narrow, as proved by the deposits of the Narbada Valley.

The Breaking up of Gondwanaland,

There is no doubt that Madagascar was severed from Africa shortly afterwards, though there is reason to believe that the strait was quite a narrow one, but on the Indian side the link seems to have remained unbroken until well into the Tertiary.

The general instability of the earth's crust in the Middle Cretaceous is reflected in the further folding of the southern part of South Africa, followed by severe fracturing of the coast-belt, the great faults, which run parallel to the folds, having down-throws on the seaward side of as much as from one to over two miles.

In addition a great bending of the crust took place along the line following the Lebombo Range, continuing through Eastern Natal into Pondoland. To the west thereof elevation occurred, and the Karroo beds are found at great altitudes, while to the east they are bent down so as to dip below sea-level. Along with the severe flexuring this coastal strip became broken through by faults, which usually trend north-eastwards, towards Madagascar, so that the separation of that island was doubtless accomplished at this particular time, namely, during the middle of the Cretaceous.

Contemporaneous igneous activity is evinced by the flooding of the Deccan in India by basalt outpourings of enormous extent, while both Northern India and Western South America were crumpled up and the strata thus folded injected with igneous matter on a vast scale. In Africa the crust was perforated by numerous volcanic pipes into which was squeezed from below the peculiar blue-ground (kimberlite) in which the diamond occurs.

Development of the Atlantic Basin.

In places the earth movements were so considerable, even during the Tertiary, that one cannot draw any reliable conclusions as to the former extension of the land-masses merely from a study of the shapes and depths of the present ocean basins; still it will be profitable to note several features that they exhibit.

In the Indian Ocean the only peculiarity is an irregular ridge from 1 to 2½ miles deep linking South Africa with India via Madagascar, the Seychelles, Chagos, Maldive and Laccadive Islands. Mauritius, Bourbon, and Kerguelen are recent volcanic excrescences upon the floor.

In the North and South Atlantic, however, the most extraordinary feature is the submarine ridge covered by only from one and a third to two miles of water extending down their entire length and always nearly midway between the shores on either side. It forms a remarkably strong piece of evidence in support of the

hypothesis submitted. In the South Atlantic at opposite ends of this swelling stand the Islands of Ascension and Bouvet, in the middle the Tristan da Cunha group. From the latter there extends in a north-easterly direction to the neighbourhood of Mossamedes an extremely narrow ridge dividing the eastern half of the ocean into two large basins. In the opposite direction lies another, but less regular and lower, ridge crossing to the southern end of Brazil.

Elevation of the ocean floor to the extent of from 10,000 to 15,000 feet would bring about the union of the two continents and also develop a mid-Atlantic land. That along the Atlantic border subsidences have occurred, recent yet of surprising magnitude, is indicated by the remarkable submarine extension of the mouth of the Congo River, soundings having proved a nearly straight trough in the even and regularly dropping ocean floor traceable fully 130 miles out to sea, where the depth is no less than 7,500 feet.

Realising the magnitude of the changes that might have occurred along the coasts, one would not put too much weight upon the extraordinary resemblances in outline between the opposite coast-lines of Africa and South America, were it not that the geological peculiarities of the two areas are so amazingly similar; not only does this apply to the South but also to the North Atlantic.

Throughout the whole length of this ocean, almost as though uninterrupted by it, one finds on the opposite sides the same fold-systems, geological series, fossil floras and faunas, intrusive and volcanic rocks. Allowing for some late Tertiary deposition and upheaval and for some coastal erosion, the nearest existing exposures are such that they could well have been only a few hundreds of miles apart originally. Some of the geological parallels have already been remarked upon, but many others exist, for example the unique alkaline igneous rocks of the opposite coasts as noted by Brouwer, while just recently Dr. P. A. Wagner has pointed out to me that the crystalline forms among the Brazilian diamonds resemble those of S.W. Africa more than the latter do those of the Union.

Our hypothesis starts with the assumption that the Continent was first of all severed by great tear-lines and that these fragments then started to move apart, just as though driven asunder by the centrifugal forces set up through spinning around the polar axis The action is to be conceived as a slipping of the outer part of the crust upon its yielding foundation and the phenomenon could indeed be compared to the gradual opening out of cracks developed in a sloping asphalt pavement.

The Fold Ranges encircling the Fragments of Gondwanaland.

The widening clefts just mentioned are regarded as becoming occupied by the oceans and as having continued to broaden down to the present day. Around the periphery of Gondwanaland strata had been accumulating over a truly vast period—from the Carboniferous to the Tertiary—and it may be surmised that it was due to this marginal weakening by which the Continent became

deprived of its lateral support that collapse took place around its borders.

In drifting apart the segments of the crust perforce would have had to squeeze up in front of them the strata composing this belt of weakness; hence the latter would have been thrown up into encircling folds. These are made by the Andine Ranges on the west, passing through Venezuela and continued as the Atlas-South European-Iranian-Himalayan folds on the north, the Malay-Polynesia-New Zealand crumplings on the east, and the West Antarctic belt on the south, joining with Patagonia and thus completing the circle.

These folds absorbed the lateral thrust and checked further spreading, but the pressures within the crust became so enormous that vast quantities of igneous matter were forced out along the belts of crumpling in the form of basalt or consolidated below ground as granite. Inside this girdle the strata would have been in tension in places, and thus an explanation is obtained for the peculiar shapes of the Red Sea and Arabian Gulf, as due to the opening of tears in the crust, and for the remarkable system of trough-faulting extending down through Eastern Africa—the great Rift Valley.

A striking feature about the encircling folds, which all date from the Tertiary, is the inflections that they make at several places, thus giving us the clue to their origin. For example, the Andine system doubles back sharply upon itself both near Trinidad and at South Georgia, such nodal points having been less yielding to the great lateral thrust and having resisted better, while the region in between moved for over a thousand miles further westwards, more so in the south than in the north. In the case of India the peninsular portion squeezed itself bodily for hundreds of miles in a north-westerly direction between "jaws" formed by Afghanistan on the one side and Burmah on the other.

That movements of such a kind and of so great a magnitude as are here postulated are not purely hypothetical is indicated through the comparisons of longitude observations of certain observatories in England and in the United States taken over a lengthy period, that can only be interpreted as implying the actual drifting apart of these countries at the present day by an amount reckoned at several yards per annum.

Life in Africa during this Time.

Turing our attention now to the life of the Continent during its dismemberment, we shall consider first that of Africa. During the Jurassic and Cretaceous epochs animals were free to roam northwards so far as the shores of an ocean—of which the Mediterranean is but a remnant—that covered large parts of Arabia, Palestine, Egypt, Tripoli, Algeria, and Morocco.

Chief among the vertebrates were the Dinosaurs, some of which were of truly enormous bulk, such as the gigantic Cretaceous *Brachiosaurus brancai* of German East Africa, which must have had a length of 100 feet; on the Bushmans River in Alexandria

Schwarz found parts of the femur of a similar animal perhaps nearly as large.

Isolated at the close of the Cretaceous, even from Asia, a fauna developed—so far known only from Egypt and the Victoria Nyanza—peculiarly African, including primitive whales (*Zeuglodon*) and sea-cows (*Sirenia*), gigantic land tortoises, ostrich-like birds, archaic Carnivora (Creodonta), and various primitive Proboscidea such as the *Mastodon* and *Dinotherium*. Conspicuous is the absence of the rhinoceroses, tapirs, and Equidae (horses), which at that very time (Early Tertiary) were living in Europe.

In the Miocene by the emergence of the Iranian-Himalayan fold-ranges Northern Africa became linked to Asia, India, and Europe, and an interchange of forms took place, though evidently not upon an extensive scale, for even in the Pleistocene the fauna in that part of Africa was still typically Ethiopian. Among the contributions to Eurasia were the Proboscidea and ostriches, while the immigrants were the rhinoceros, camel, lion, and other Felidae, Equidae, bear, wild cattle, buffalo, and numerous antelopes.

Together with the indigenous fauna these forms spread south, so that we find the remains of the *Mastodon* in the Vaal River gravels near Barkly West and extinct species of horse and buffalo in various parts of the Cape and Orange Free State.

This incursion of northern forms was doubtless assisted by the cold of the approaching Pleistocene Ice Age, which pressed them into the Oriental and Indo-Malay region also. It is known that, during this particular period, glaciers descended the flanks of Mts. Kenia and Kilimanjaro, and what more likely than that the spread of the temperate floras along or across the equatorial belt was facilitated, if not wholly brought about, by the prevailing lower temperature of the time.

It was during the Tertiary that the crust subsided along narrow belts forming the well-known "Rift Valleys" of Africa, and the fracturing was attended by extensive volcanic eruptions; some of the volcanos are still active. The northern end of the belt of subsidence enters the Red Sea, while a strip of tilted and fractured Miocene marine strata inland from Beira indicates the southern extension of this lengthy arc along which the sides have been drawn apart, allowing a narrow width of strata to drop between them.

The Reunion of Madagascar and Africa.

Under such circumstances the temporary reunion of Madagascar to the mainland in about the Miocene would have been not only possible, but very probable, receiving some support from the fact that this large island shows the effects of tilting and of fracturing, and is still subject to earthquake shocks, while it and the other members of the Mascarene Group are surrounded by barrier reefs of coral pointing to recent subsidence. Several of the islands, Mauritius for example, are of recent volcanic origin and possess differing faunas.

Both the floras and faunas, particularly the latter, indicate such a union, for the modern tortoises of Madagascar are like the gigantic fossil forms of Egypt and the Victoria Nyanza, while we have also an instance in the Malagasy hippopotamus. This island has yielded a number of species of extinct giant lemurs, a family still living not only there, but in Central Africa and Malaysia as well, hence the name "Lemuria" given to this land-bridge connecting Madagascar, their supposed centre of origin, with Africa and the Malay region.

Another view, based upon the fact that the *Lemuridae* are well represented in the Eocene of Europe, is that they originated there, entered Madagascar from the west, and became isolated in that island, their development therein being largely due to the practical absence of Carnivora. On the other hand Dr. H. F. Standing has shown that among the sub-fossil lemurs of Madagascar there are closer analogies with the monkeys of South America than with those of the Old World. Moreover, since they possess degenerate characters the parent stock probably originated on the Afro-American land-mass.

Severing of South America from Africa.

Accordingly, turning to the Argentine, we find a marked geological parallel with the Swellendam-Heidelberg districts of the Cape, inasmuch as estuarine variegated marls of Cretaceous Age rest in valleys cut in the equivalents of the Cape fold-ranges. The ocean did not penetrate here until Eocene times, and the fauna is that of the now-developing South Atlantic Ocean, typically Antarctic and neither Pacific nor North Atlantic in its facies, thus proving that the Argentine-Brazilian section of Gondwanaland still extended considerably further eastwards towards Africa.

In fact, since North Atlantic forms do not make their appearance on the South American coast until the Pliocene, it has to be presumed that the latter was divided from Africa at the end of the Cretaceous by an extremely narrow strait. Such a view receives weighty support, first, from the absence of Cretaceous beds along the two opposed coast-lines, between the Argentine and Bahia and between the Cape and Angola respectively, and secondly, from the fact that the strata of that epoch represented further to the north in each case possess faunas not only very closely related to one another, but of the type characterisng Morocco, Tunisia, and Portugal—a North Atlantic assemblage in fact.

Apparently the breach that was developing between Africa and South America in the Upper Cretaceous commenced to broaden from the north, allowing the North Atlantic to enter and ultimately to join up with the already formed South Atlantic-Indian Ocean.

That the two continents were separated by water at the commencement of the Tertiary is shown by the marked dissimilarity between the mammalian faunas of the two countries, the four typically Ethiopian orders being unrepresented in South America for example; on the other hand the analogies displayed between the monkeys of the latter region and the Madagascar lemurs require

some explanation. In order to meet the needs of botanists such as Hooker and Engler, who have pointed out certain strong floral resemblances between the two continents, the reasonable assumption can be made that the gap, though wide enough to prevent animal migration on the whole, was for a time not so broad as to prevent the crossing of certain plants.

On the assumption that the breach widened from the north, the opposed shore-lines would have approached closest in the south, namely in about a line from Uruguay to the Cape. A little farther on it is pointed out that a much more northerly connection might also have come into being at about the same date.

Cut off by the Upper Cretaceous Ocean, just as Africa was, South America started to evolve a marvellous assemblage of mammalian life, such as the gigantic ground-sloths and armadillos, the remains of which are preserved in the Tertiary deposits of Eastern Patagonia.

The Reunion of South America and Australia.

Meanwhile the several sectors of Gondwanaland were moving apart from one another at a more rapid rate and, as explained earlier, they were pushing up in front of them a practically complete circle of fold-ranges, bringing above the surface of the ocean parts of the crust that had been forming the sea floor for a very lengthy period.

In South America this resulted at the beginning of the Miocene in the elevation of the Andes, a chain of crumpled beds injected with igneous matter, prolonged southwards through Graham Land and Western Antarctica, and continued in the folds of New Zealand and Eastern Australia. Von Ihering, Ortmann and Hedley have emphasised the great resemblances in the marine molluscan faunas of this date in Patagonia, Australia, and New Zealand, indicating a migration of forms along the littoral of a Miocene ridge.

Zoologists have had occasion to remark upon the relationships displayed between the marsupials of Patagonia and those of Australia and Tasmania, and when to this is added similar evidence from among the fossil turtles, the fresh-water fishes, the decapod Crustacea, the land Mollusca, and the earth-worms, there can be no reason to doubt that a land-bridge connected these parts of the globe. The botanical affinities, as shown by Hooker, Hemsley, and Bentham, point strongly in the same direction, the relationships being much more marked than with Africa.

It is essential to note that this period, the Miocene, was one of remarkably mild climate, which alone could have permitted the migration of terrestial life via the Antarctic Circle.

Atlantis.

Turning to the north of South America, but arguing wholly upon analogy, we are able to detect a second locality where a connection with Africa could have been established during the Tertiary, for between Venezuela and Morocco the Cretaceous and

Tertiary beds were buckled up into folds, as can well be seen in the Atlas Ranges.

For reasons given already any such link would with more likelihood have consisted not of an isthmus, but rather of a chain of islands, of which the Cape Verde and Canary Islands would constitute the remnants. It is for biologists to determine whether the evidence favours either the single or the double connection, and, if the former, just where it should be placed.

It is peculiarly interesting to recall that the reputed Continent of Atlantis, from which this ocean basin derives its name, was believed to have lain in this quarter, and that according to certain students of the question the story of its engulfing is an actual tradition and no mere myth, its submergence being regarded by them as having taken place during the existence of mankind.

In concluding, the many imperfections in the presentation of this discourse are admitted, for on certain points, as it happens, our knowledge is of the vaguest. The many sided nature of the problem actually demands for its solution the collaboration of specialists in the several branches of science concerned.

LIST OF PAPERS READ AT THE SECTIONAL MEETINGS.

Section A.—Astronomy, Mathematics, Physics, Meteorology, Geodesy, Surveying, Engineering, Architecture and Irrigation.

MONDAY, JULY 11, 1921.

1. Presidential Address on "Stellar Distances, Magnitudes and Movements," by J. Lunt, D.Sc.

TUESDAY, JULY 12.

2. Purification of Sewage by the Activated Sludge Process: R. J. Norris, M.R.San.I.

WEDNESDAY, JULY 13.

3. Asphalt in Relation to Road Construction: D. B. W. Alexander.
4. Some Notes on the Occurrence of Even Harmonics in Electrical Pressure and Current Waves: H. Clark, B.Sc., A.M.I.E.E.

Section B.—Chemistry, Geology, Metallurgy, Mineralogy and Geography.

TUESDAY, JULY 12.

1. Presidential Address: "The Atomic Theory in 1921," by J. Moir, M.A., D.Sc., F.I.C.

WEDNESDAY, JULY 13.

2. Alcohol fuels for internal combustion engines: C. W. Petchell.
3. Notes on the chemical control of Cattle Dipping Tanks: C. O. Williams, B.Sc.
4. Condensed Milk in South Africa from the chemist's point of view: A. Kloot, B.Sc., A.I.C., and L. Hyman.
5. On the mechanical analysis of Soils containing heavy Minerals: B. de C. Marchand, B.A., D.Sc.

SECTION C.—BOTANY, BACTERIOLOGY, AGRICULTURE AND FORESTRY.

THURSDAY, JULY 14.

1. Presidential Address on "Some Aspects of Botany in South Africa and Plant Ecology in Natal," by J. W. BEWS, M.A., D.Sc.

TUESDAY, JULY 12.

2. Natal species of the genus *Cassia*: HELENA FORBES.
3. An account of the Flora at Isipingo: HELENA FORBES.
4. The Plant Succession in a type of Midland Tree Veld in Natal: R. D. AITKEN, M.Sc.
5. The Aeration Systems of certain Natal plants: a preliminary account: G. W. GALE, B.Sc.
6. Notes on some Fungi in the air of sugar mills and their relation to the sugar industry: P. A. VAN DER BIJL, M.A., D.Sc. ...
7. An interesting abnormality of *Polyporus lucidus*: P. A. VAN DER BIJL, M.A., D.Sc.
8. Interspecific hybrid and backcross of Foxglove: E. WARREN, D.Sc.

FRIDAY, JULY 15.

9. Notes on some interesting or little known South African Fungi: P. A. VAN DER BIJL, M.A., D.Sc., F.L.S.
10. Protonemal developments of Mosses: H. A. WAGER, A.R.C.S.
11. The genus Passerina and its distribution in South Africa: D. THODAY, M.A.
12. The potency of Pepper-tree pollen as a cause of Hay Fever: G. POTTS, B.Sc., Ph.D.
13 A method of Veld-estimation in relation to Lamziekte: A. O. D. MOGG, B.A.
14. Agricultural experiment: its design and interpretation: E. PARISH, B.Sc.

SECTION D.—ZOOLOGY, PHYSIOLOGY, HYGIENE AND SANITARY SCIENCE.

TUESDAY, JULY 12.

1. Presidential Address on "Some recent Advances in Zoology and their relation to Present-day Problems," by H. B. FANTHAM, M.A., D.Sc., F.Z.S.

MONDAY, JULY 11.

2. The experimental infestation of freshwater snails, with specific reference to the Bilharzia parasite: F. G. CAWSTON, B.A., M.D.
3. Birds and bilharziasis. F. W. FITZSIMONS, F.Z.S., F.R.M.S.
4. The life-histories of some Trematodes occurring in South Africa: ANNIE PORTER, D.Sc., F.L.S.

WEDNESDAY, JULY 13.

5. The natural history, including the geology, of Durban: E. C. CHUBB, F.Z.S., F.E.S.
6. The life-history of species of *Heterodera* in South Africa: J. SANDGROUND, M.Sc.
7. A note on *Ortalia pallens*: R. H. T. P. HARRIS.

FRIDAY, JULY 15.

8. Some Protozoa found in certain South African Soils: H. B. FANTHAM, M.A., D.Sc., and ESTHER TAYLOR B.Sc.
9. Some parasitic Protozoa found in South Africa, IV: H. B. FANTHAM, M.A., D.Sc.
10. Nature's methods of screening light in the eyes of Mammals, Birds, Reptiles and Amphibia: LINDSAY JOHNSON, M.D.
11. What is the reservoir of South African horse-sickness?: G. VAN DE WALL DE KOCK, M.R.C.V.S.

Section E.—Anthropology, Ethnology, Native Education. Philology and Native Sociology.

WEDNESDAY, JULY 13.

1. Presidential Address on "The Claims of the Native Question upon Scientists," by C. T. Loram, M.A., LL.B., Ph.D.

MONDAY, JULY 11.

2. Bantu industries: D. A. Hunter.
3. Bantu literature reviews: D. D. T. Jabavu, B.A.

TUESDAY, JULY 12.

4. Errors in the Fourth Dimension; Rev. W. A. Norton, M.A., B.Litt.

WEDNESDAY, JULY 13.

5. Natives and agriculture: W. Hammond Tooke.
6. The heavenly bodies in South African mythology: Rev. S. S. Dornan, M.A.
7. Two Ntu problems: Rev. W. Wanger.
8. Hymen in clover: Rev. A. T. Bryant.
9. The Bantu idiomitist in the field of philology: Rev. W. A. Norton, M.A., B.Litt.
10. Sesuto praises of the Chiefs: Rev. W. A. Norton, M.A., B.Litt.
11. Regiments of the House of Moshesh: Rev. W. Norton, M.A., B.Litt.

FRIDAY, JULY 15.

12. Native religious rites: Rev. A. T. Bryant.
13. An educational experiment: H. S. Keigwin, M.A.
14. On several implements and ornaments from Strandlooper sites: J. Hewitt, B.A.

Section F.—Education, History, Mental Science, Political Economy, General Sociology and Statistics.

WEDNESDAY, JULY 13.

1. Presidential Address on "Observations and Proposals for the Stabilisation of Money Values," by W. A. Macfadyen, M.A., LL.D.

TUESDAY, JULY 12.

2. The taxation of land values: Geo. Burgess.

WEDNESDAY, JULY 13.

3. The function of a School of Art in the life of the community: O. J. P. Oxley, A.R.C.A.
4. Irving Fisher's proposals for stabilising the value of money: Mrs. Mabel Palmer, M.A.
5. Archival problems in South Africa: C. Graham Botha.
6. The preservation of our national monuments: C. Graham Botha,
7. Decentralisation in University education and research: J. E. Holloway, D.Sc.

FRIDAY, JULY 15.

8. Synaesthesia: a continuation of chromaesthesia: Bertha Stoneman, D.Sc.
9. A curiosity of mediaeval French literature: R. D. Nauta.

ALCOHOL FUELS FOR INTERNAL COMBUSTION ENGINES.

By W. Petchell.

Read July 13, 1921.

For a long time it has been apparent that the only substitute for petrol for internal combustion engines which could be obtained in unlimited quantities without robbing Nature's resources is alcohol.

Its disadvantages are its low calorific value and low vapour pressure.

Its advantages are:—

It does not carbonize in the cylinder to anything like the extent that petrol does. Sooted-up plugs are practically unknown when running on alcohol fuels.

Its comparative safety from fire. Burning alcohol can be extinguished easily by water.

The explosion in the cylinder is not so sudden as with petrol. Pre-ignition under ordinary circumstances will never occur, so that a car can be driven uphill on top gear until the engine almost stops without any of the hammering that occurs with petrol.

Various methods have been proposed and tried with a view to remedying the disadvantages of alcohol as a fuel. In order to increase the calorific value the addition of benzol, naphthalene, and various other substances has been tried. An excellent mixture is 60% of alcohol and 40% benzol. This mixture gave excellent results, but would not start easily when the engine was cold. This called for a special carburetter or a small quantity of a more volatile fuel for starting purposes. Then the supply of benzol is limited.

The low vapour pressure and consequent difficulty in starting with alcohol only is a very serious drawback to using it in the engines of motor cars, etc., as the average driver will not go to the trouble of having a second tank fitted and carrying a supply of a fuel which is easy to start up on. To obviate this several methods have been tried, the two most common being the addition of sulphuric ether, and saturating the alcohol with acetylene.

Some years ago the mixture of acetylene and alcohol was tried in America with a certain amount of success, but was abandoned on account of the then high price of alcohol and low price of petrol. The drawback to this mixture is that it soon gets stale. The calorific value is very slightly improved, as the alcohol will not absorb more than about 0·8% of acetylene by weight. There is also a possibility of the acetylene acting on the copper pipes leading to the carburetter, etc.

Mixtures of alcohol and ether were proposed and tried several years ago, but until the Natalite patent was applied for there was no proposal to use ether in such large percentages.

Of all the alcohol fuels that I have tried I have found that Natalite was the most satisfactory substitute for petrol. In the early stages of manufacture we had innumerable complaints. Many were very puerile, such as that the fuel ate away the cylinder walls. I watched the exhaust valves as I expected to find a certain amount of pitting there, but I never found any trouble. There were also complaints of corrosion of tanks. In the early stages this might have been true in a slight degree, as we had to use wood naphtha as a denaturant. Since the use of Simonsen's oil and pyridine as denaturants has been allowed these troubles have ceased. Wood naphtha was always undesirable in a motor fuel. It was frequently impure and contained small quantities of acetic acid and also liberated acetic acid on combustion. Its calorific value was also low.

Pyridine on the other hand is an excellent denaturant. Its unpleasant smell renders any alcohol fuel unpotable. It is difficult to separate out and has the great advantage of liberating ammonia on combustion, thus neutralizing the effect of any acid that may be formed by the combustion of impure alcohol.

Simonsen oil is simply crude petroleum with the asphaltic fractions separated. It is useful as a fuel and a very good denaturant which is very difficult to separate out. It also has a high calorific value.

From time to time the bogey of corrosion is brought up in connection with alcohol fuels, but I can confidently say after considerable experience that it is non-existent if a pure alcohol is used, say 96% alcohol, but if there is much aldehyde present there is great danger of corrosion, as here again acetic acid is liberated on combustion. I ran a car 25,000 miles on Natalite: at the end of that time the engine was opened up and thoroughly examined. There was no sign of corrosion anywhere. The colouring matter is a slight drawback, even though the quantity is so small, amounting to about ½ oz. of methyl violet to 3 tons of fuel. Yet with continuous use this small amount collects in the carburetter. It would be well if the Excise authorities could see their way to do away with this requirement.

While on this subject I should like to pay a tribute to the Union Government and the Excise authorities for the sympathy and courtesy which they have always extended to us. It is for this reason that I think that we can claim that South Africa is one of the first countries to make a practical success of an alcohol motor fuel.

It is often claimed by the inventors or authors of alcohol motor fuels that the same mileage can be obtained with their fuels as with petrol. I have never found this to be so with the exception of the mixture of benzol and alcohol previously mentioned, which gave results very nearly equal to petrol. In this connection I am talking of course of standard cars with standard petrol carburetters.

We have put down a testing set at Merebank for testing the comparative values of liquid fuels suitable for motor cars and other

engines. It consists of a one and a half kilowatt single cylinder 4 cycle internal combustion engine with generator combined, working through an air resistance so that any desired load can be obtained. It was my intention to have the work done shown on a recording wattmeter, but this has not been delivered yet, so I have had to be content with an ordinary voltmeter and recording ammeter. Although this is rather a crude testing set I have got some very interesting data, which, if not strictly accurate, are much more accurate than any tests which could be carried out on the road.

According to the calorific value Natalite has only 72% the value of petrol. The value is approximately 12,000 B.T.U. I have not been able to have it taken in a calorimeter, but have taken petrol as 18,000 B.T.U. and alcohol as 11,500.

I have had to calculate the calorific value of ether from Dulong's formula corrected by Redtenbacher, which gave an approximate value of 14,000 B.T.U. for ether, corresponding to a calorific value of 12,000 for Natalite.

In the running tests with the testing set, an average of five different runs was taken with the following results:—

At full load Natalite gave 75·6 % compared with Shell petrol.
At 2/3 load Natalite gave 79·65% compared with Shell petrol.
At 1/2 load Natalite gave 80·27% compared with Shell petrol.
At 1/3 load Natalite gave 86·85% compared with Shell petrol.
This gives an average on all loads of 80·59%.

The higher efficiency at 1/3 load is rather extraordinary. I think that the efficiencies at all loads would be increased by supplying hot air to the carburetter so as to vaporize the fuel better. This is the more necessary as the engine has a fairly long induction pipe. However, the conditions were similar to those met with in the majority of motor car engines.

It is rather difficult to explain the difference of 8% efficiency over the calorific value of the fuels. The thermal efficiency of the engine working on the alcohol fuel is certainly higher than that of the petrol engine on account of the lesser quantity of heat lost in the exhaust owing to less air being required for combustion, but this does not account for all the difference. In each case the needle of the carburetter was closed until the engine started to miss fire and then opened again very gradually until the missing stopped. The same carburetter setting was kept for all loads. These results agree very nearly with those that I get on my car on the road, viz., a mileage of practically 80% of that of petrol. The efficiency at the lower loads is very good when it is considered how much running about is done at one-third or half load. In my opinion an engine as built for petrol is very suitable for alcohol fuel. One often hears people extolling a new alcohol fuel, saying that the compression of the present engines should be increased and wonderful results would follow. I have tried increasing the compression to 110lbs., but only got slightly better results. I think that the compression would have to be raised to about 150lbs. per square inch or higher to get really good results. The

difficulties of starting a touring car with, say, 150lbs. compression would be great and would require a compression relief gear. Then again with throttle control there would be very little flexibility. Every motorist knows that flexibility is one of the chief aims of every designer of touring car engines, so I do not think that engines with a compression much higher than at present will be adopted.

Then, again, if any of the mixtures of alcohol and other substances added to increase the vapour pressures were subjected to much higher compression, pre-ignition would occur.

In a stationary engine with alcohol alone a compression of 200lbs. per square inch could be adopted. This with a hit and miss governor would probably be a good deal more economical than a petrol engine, and would very nearly approach the Diesel engine in thermal efficiency.

In my opinion the carburetter of the petrol engine leaves much to be desired if an alcohol fuel is to be used, and that if alcohol alone is to be used a new design will be necessary.

At the present time alcohol with different mixtures serves for adaption to the present type of petrol car, and for some time to come will carry us over the transition stage, but in the end I feel sure that alcohol alone, denatured of course to render it undrinkable, will come out on top, as none of the substances added increase its thermal efficiency to anything like the extra cost that they entail. At the same time as before mentioned alcohol mixtures will tide over the present, but will be discarded when suitable carburetters are fitted, and a plentiful supply of alcohol obtainable everywhere.

I think that with a suitable carburetter alcohol would give very much better results than any of the mixtures, and the present carburetter.

The most suitable one would have to break up the alcohol into a spray and be fed with air at a temperature just high enough to vaporize it. The proportions between fuel and air should be nearly constant at all speeds. For the general public a fixed jet should be fitted. Alcohol having such a much wider explosive range than petrol, a big waste of fuel can take place without the driver being aware that his mixture is much too rich. I am frequently told of cars pulling splendidly on Natalite, but the consumption is excessive. In almost every case of this sort the carburetter has a variable jet which is too much open.

It would be an advantage to have the vaporizer heated up to facilitate starting. This could easily be done by an electric resistance, as is the case, I believe, with some of the paraffin carburetters. It is this difficulty in starting with alcohol alone that has to be overcome, and until there are plentiful supplies of denatured alcohol of good quality to be obtained in every village sufficient attention will not be paid to overcoming the difficulty.

NOTES ON THE CHEMICAL CONTROL OF CATTLE DIPPING TANKS.

By C. Williams, B.Sc., A.R.C.S.,
School of Agriculture, Cedara.

Read July 13. 1921.

In a previous paper by the writer on this subject published in the Journal of this Association for May, 1915, the need for a periodical chemical analysis of arsenical dip fluids from cattle dipping tanks was emphasised. Although such apparatus as the "Isometer" and the "Champion Dip Testing Apparatus" are very useful as affording a quick method of ascertaining, approximately, the amount of sodium arsenite in a dip fluid, they are liable to serious errors in careless hands, while no account is taken by these methods of the arsenic that is present in the fluid in the oxidised form as arsenate. Although it may be true that under practical conditions the amount of oxidation in dipping tanks is not usually serious, yet cases come under the writer's notice from time to time in which the amount of oxidised arsenic in the tank is too serious to be ignored. As an illustration there are appended the results of the periodical analysis of the fluid taken from both tanks on the Cedara Experiment Farm during the past two years. After each analysis the fluid was made up approximately to standard strength, assuming that the oxidised arsenic has half the insecticidal strength of the unoxidised form:—

NEW TANK.

Date of Analysis.	Amount of Arsenious oxide: As_2O_3	Total Arsenic: (Calc. as As_2O_3	Remarks.
	per cent.	per cent.	
October 28, 1919	0·092	0·106	
November 1, 1919	0·107	0·111	
January 23, 1920	0·081	0·135	
March 12, 1920	0·086	0·157	
March 20, 1920	0·085	0·148	
June 3, 1920	0·146	0·148	Tank cleaned out and fresh dip put in.
August 26, 1920	0·118	0·156	
November 8, 1920... ...	0·117	0·134	
February 7, 1921	0·080	0·113	Influx of storm water into tank.
February 14, 1921... ...	0·100	0·162	
March 23, 1921	0·082	0·146	
May 19, 1921...	0·154	0·156	Tank cleaned out and fresh dip put in.

OLD TANK.

Date.	Arsenious Oxide As_2O_3	Total Arsenic calc. as As_2O_3	Remarks.
	per cent.	per cent.	
October 28, 1919	0·055	0·098	Tank cleaned out in July, 1919.
November 1, 1919... ...	0·084	0·143	
January 23, 1920	0·081	0·146	
March 12, 1920	0·054	0·105	Influx of storm water.
June 3, 1920	0·061	0·162	
August 26, 1920	0·101	0·201	
November 8, 1920... ...	0·091	0·147	Influx of storm water.
February 7, 1921	0·065	0·128	Influx of storm water.
February 14, 1921 ...	0·105	0·169	
March 23, 1921	0·075	0·176	
May 19, 1921...	0·054	0·200	

These figures show that oxidation of the arsenic proceeded continuously at a serious rate in both tanks, although they were in continuous use. The same trouble is liable to occur in other dipping tanks, and for this reason, among several others, farmers should be encouraged to forward samples periodically to the laboratory of the nearest agricultural college in order to have a proper chemical analysis made, as a check on the tests carried out by themselves.

EFFECT OF ORGANIC MATTER AND OTHER IMPURITIES ON THE RESULTS OF THE ESTIMATION OF ARSENIC BY THE IODINE METHOD.

In the laboratory at Cedara, Mohr's method of titration with standard iodine solution is utilised for the estimation of the arsenic, in both the arsenite and arsenate states.

The dip fluid is first clarified by the aid of a few cubic centimetres of either strong hydrochloric or sulphuric acid. For the estimation of the arsenious oxide the filtrate, after neutralising with sodium carbonate, is titrated with N/10 iodine, after adding an excess of sodium bicarbonate as usual.

In estimating the total arsenic, another portion of the filtrate is treated with a large excess of either concentrated hydrochloric or sulphuric acid and a gram or two of potassium iodide, in order to reduce the arsenate present to the arsenite condition. The reduction is complete after warming the flask for a few minutes, the free iodine is got rid of by means of sodium thiosulphate, and the arsenic is then estimated as before

In the dip fluid as taken out of the tank there is a fairly large proportion of extraneous matter present, besides arsenious oxide, that causes the absorption of iodine, but by the addition of an acid to clarify the fluid the greater proportion of these substances is got rid of. In order to ascertain the amount of iodine absorption actually taking place in this method of estimation, a liquid was made up of spring water containing about 10 per cent. of drainage fluid from the cow byre, thus approximating the con-

ditions obtaining in a dipping tank. Blank estimations by the iodine method were made on this solution at monthly intervals, and the results calculated to the equivalent amounts of arsenious oxide in each case, the same procedure being followed exactly as with dip fluid.

	First Analysi	After I month	After 2 months	After 3 months	After 4 months
	per cent.	per cent.	per cent.	per cent.	per cent.
1. Equivalent amount of Arsenite (calculated as As_2O_3)	0·006	0·008	0·005	0·004	0·003
2. Equivalent amount of Total Arsenic (calculated as As_2O_3)	...	0·002	0·003	0·001	0·002

It will be noticed that the addition of a large excess of concentrated acid when estimating the total arsenic gives a smaller blank figure than in the estimation of the arsenite.

In a five-day dip fluid the proportion of arsenious oxide is 0·16 per cent., so the error due to absorption of the iodine by extraneous matter is reasonably low. It may be also pointed out that by the use of a fairly close filter paper the amount of iodine absorbed in the blank estimations is slightly less than when the ordinary quick paper is employed.

To Test Effect of Excretory Matter in Dip Fluids.

It has been stated by more than one authority on this subject that the frequent addition of fresh excretory matter to the arsenical dip fluid will not only retard the oxidising action that usually goes on in such fluids, but will even cause the speedy reduction of the oxidised arsenic (as arsenate) back to the unoxidised form (as arsenite). In order to test this contention under laboratory conditions the following series of investigations were carried out, the solutions in each case being kept in stoppered Winchester quart bottles.

1. A solution of 4 grams of sodium arsenite in 2 litres of distilled water was made up and analysed immediately after. Then 10 grams of fresh dung were added to the bottle, and the contents were analysed at fortnightly intervals. The results were as follows:—

	First Analysis	After 2 weeks	After 4 weeks	After 6 weeks	After 8 weeks	After 10 weeks
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
a. Arsenite (as As_2O_3) ...	0·151	0·137	0·097	0·037	0·023	0·020
b. Total Arsenic (as As_2O_3) ...	0·155	0·154	0·154	0·152	0·152	0·154

2. A solution was made up as in (1), but 2 grams of fresh dung were added immediately after the first analysis, and the same amount added to the bottle every week.

	First Analysis	After 2 weeks	After 4 weeks	After 6 weeks	After 8 weeks	After 10 weeks
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
a. Arsenite (as As_2O_3) ...	0·151	0·151	0·117	0·068	0·039	0·028
b. Total Arsenic (as As_2O_3) ...	0·155	0·154	0·155	0·154	0·154	0·154

3. The third solution was made up as in (1) with 10 grams of fresh dung added immediately after the first analysis. After oxidation had well set in (after a period of 4 weeks) weekly additions of fresh dung were made.

	First Analysis	After 2 weeks	After 4 weeks	After 6 weeks	After 8 weeks	After 10 weeks
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
a. Arsenite (as As_2O_3) ...	0·151	0·139	0·103	0·060	0·030	0·021
b. Total Arsenic (as As_2O_3) ...	0·155	0·152	0·154	0·154	0·154	0·154

The figures in these tables show that weekly additions of fresh dung to stoppered bottles containing solutions of sodium arsenite did not prevent the progressive oxidation that goes on in the original inoculated fluid.

Since the above experiments were carried out the writer has had access to two papers by Green* in which he states that he has succeeded in isolating a bacterium causing oxidation of arsenite to arsenate in dipping tanks, and also an organism which brings about the opposite change. He maintains that the latter organism does not thrive in a dilute dung decoction and that there must also be present small amounts of urine. It is therefore quite possible that in the experiments of which the results are given above this was the missing factor, or rather, the one which was present in an insufficient amount.

This, however, would not explain the continuous oxidation that has been going on in the two tanks at Cedara. In these tanks a proprietary dip containing a certain proportion of a coal-tar disinfectant in its composition was used throughout the period in question, while to the old tank, in addition, there has been added a few gallons of a similar type of disinfectant occasionally. Chapin† points out that too little disinfectant in the tank is worse than none at all, because the reducing organisms are more sensitive to it than those causing oxidation. It, therefore, seems probable that this has been the fault in the control of the Cedara dipping tanks. It is, therefore, proposed to clean out both of these tanks, put fresh dip fluid in, but to avoid in the future the

* H. H. Green: Fifth and Sixth Reports of the Director of Veterinary Research, pp. 611 et seq.

† R. M. Chapin: "Studies on Changes in the Degree of Oxidation of Arsenic in Arsenical Dipping Baths," Bulletin No. 259 of U.S. Dept. of Agriculture.

addition of any disinfectant to one of them, while adding the usual amounts to the other. In this way it is hoped to be able to settle this point definitely, for the dip fluids will be analysed at regular intervals and kept under chemical control.

Keeping Powers of the Standard Solutions of Iodine used in Testing Dip Fluids.

From time to time complaints have been received from farmers and Government officials who have to test the strength of the arsenical fluids of dipping tanks, that the results of their tests are anomalous. In order to ascertain whether that may not sometimes be due to a deterioration in the strength of the iodine solution used in their apparatus, a few bottles of these standard solutions were bought from one of the dealers and tested periodically against a standard solution of arsenite. Altogether nine bottles of standard solutions for various kinds of dip fluids were tested, and it was found that all the solutions were reasonably near the standard strength that they were supposed to represent. They also kept their strength fairly well for three or four months, the loss of strength in that period being not more than about 5 per cent., but the deterioration of strength after about a year was very marked in most cases, although the bottles were kept in a cupboard with their stoppers on. It is conceivable that great carelessness will often be observed in the storage of the iodine solution on the part of farmers, who may often use a solution that has been in the house for a year or more. Under these conditions it is probable that large errors in the test will arise, and will explain the peculiar results that are often obtained by them.

The Effect of the Addition of Certain Salts to Solutions of Arsenite and Arsenate of Soda.

1. *On Arsenite of Soda*:—

In order to test whether the presence of certain salts in the water used for making up dip fluids has any appreciable effect or not on the solubility of the arsenic some arsenite of soda was dissolved in distilled water and to this fluid certain solutions were carefully added until no further precipitation of the arsenite took place. The results are recorded in the following table:—

Proportion of Arsenious Oxide in the solution originally $=0{\cdot}148\%$.

Salt or Oxide added.	Proportion of As_2O_3 found in the Solution after addition of the reagent.	Amount of each substance that had to be added (calculated as parts per 100,000 of the Arsenic solution).
	per cent.	
1. Ferrous Sulphate. ...	0·114	143
2. Ferric Chloride ...	0·127	110
3. Calcium Oxide (as Lime Water) ...	0·048	75
4. Magnesium Snlphate	(No appreciable precipitate produced.)	

2. *On Arsenate of Soda*:—

In order to find out whether the above compounds precipitate any appreciable amount of the oxidised arsenic in the dipping tank, a solution of arsenate of soda was made up and tested as in the case of the arsenite of soda.

Proportion of Arsenate (calculated as As_2O_3) in the solution originally $=0{\cdot}114\%$.

Salt or Oxide added.	Proportion of Arsenate (calculated as As_2O_3) found in the Solution after addition of the reagent.	Amount of each substance that had to be added (calculated as parts per 100,000 of the Arsenate Solution).
	per cent.	
1. Ferrous Sulphate ...	0·023	270
2. Ferric Chloride ...	0·040	163
3. Calcium Oxide (as Lime Water) ...	0·008	75
4. Magnesium Sulphate	(No appreciable precipitate produced.)	

The above results show that spring water containing an appreciable amount of saline matter (especially salts of iron and of the alkaline earths), when used in making up a dip fluid, may cause a serious precipitation of both the unoxidised and oxidised arsenic in a dipping tank, and the weakening of dip fluids in tanks might sometimes have possibly been due to this cause. Of course, salts of sodium and potassium in the water would have no such effect.

Summary.

1. When estimating the arsenic in ordinary dip fluids by titration with standard iodine solution, the error due to absorption of the iodine by the organic matter in the dip fluid is very small, and even negligible, if the fluid is first clarified by the aid of a few cubic centimetres of either strong hydrochloric or sulphuric acid.

2. It has been stated by more than one authority that the frequent addition of fresh excretory matter to the dipping tank will not only retard the oxidising action that usually goes on in arsenical dip fluids, but will even cause the speedy reduction of the oxidised arsenic. According to this contention, a tank in constant use will not show any appreciable oxidation, but experience has shown that some dipping tanks, although fulfilling these conditions, still show serious weakening of strength by oxidation. It is, therefore, very necessary that farmers should forward samples periodically to a laboratory in order to have a proper chemical analysis made, as a check on the tests carried out by themselves.

3. The standard solutions of iodine supplied by certain dealers to farmers for testing their dip fluids seem to keep up their strength fairly well for about three or four months, but after that period has elapsed they usually deteriorate fairly rapidly.

4. Water containing an appreciable amount of saline matter (especially salts of iron and of the alkaline earths), when used in making up a dip fluid, may cause a serious precipitation of both the oxidised and the unoxidised arsenic in the dipping tank. Salts of sodium and potassium in the water would have no such deleterious effect.

A PRELIMINARY ACCOUNT OF SOME INVESTIGATIONS ON LEAF-AERATION IN CERTAIN NATAL PLANTS.

By G. W. Gale, B.Sc.,
Union Government Research Scholar.

Read July 11, 1921.

The method of estimating the intercellular space content of Angiosperm leaves by noting their increase in weight when injected (under reduced pressure) with water, dates back to 1721, when Christian Wolff first made experiments of this sort. In 1854, Unger made an extensive series of such measurements on various species chosen apparently more or less at random, and helped to pave the way for Haberlandt's generalization in 1914 that the aeration system of leaves is greatest under hygrophilous conditions and least under xerophytic conditions. As a corollary to this statement we know that shade leaves exhibit a greater degree of aeration than sun leaves, a conclusion confirmed by McLean's work on the tropical rain-forest of Brazil.

Last year the present writer commenced work on the aeration systems of leaves with the object of comparing, in this respect, different ecological types of the Natal flora. A brief description of the method used, and of certain necessary precautions, may be of interest. The leaves are weighed and placed in a conical flask attached by a side-exit to an air-pump; the injection-fluid enters from a reservoir placed above the flask and communicating with it by means of a tube controlled by a stopcock. The air is exhausted from the flask, and this of course withdraws also the air from the intercellular spaces. The stopcock control is now opened and fluid run in from the reservoir until the leaves are completely covered. A few more turns of the air-pump are now necessary in order to exhaust the air dissolved in the injection fluid. The flask is now disconnected from the pump, and as the air rushes in the leaves are injected. They are then taken out, dried with a linen cloth, and re-weighed. Acting on McLean's suggestion, 4% alcohol (sp. gr. ·99) is used as the injection fluid; it is too weak to cause plasmolysis of the cells, but possesses a much lower surface tension than water and hence penetrates more easily. The process of injection can actually be observed in nearly all leaves, and thus there is a guarantee that injection shall always be complete.

Unfortunately, many, particularly sclerophyllous and parallel-veined, leaves will not inject completely. In order to prevent *absorption* of the injection-fluid by the cells of the leaf it is essential to deal only with leaves which have been kept for several hours in an atmosphere saturated with water-vapour: this can be done by placing leafy twigs in water under a bell-jar for some hours before experimenting.

Several interesting results have emerged from the work already done. In the first place a criticism of the conclusions of previous writers (e.g. Haberlandt, McLean) seems to be justified. Evidence has been obtained that a well-developed intercellular space system is not *necessarily* a mesophytic character, nor a poorly-developed one necessarily a xerophytic character. Two Natal xerophytes—*Portulacaria afra*, the Spekboom, and *Avicennia officinalis*, a Mangrove—have, for instance, a larger intercellular space system, relative to both weight and volume of the whole leaf, than species growing in more "mesophytic" situations, e.g., *Fagara davyi* and *Tricalysia lanceolata* in High Veld Bush. This indicates that another factor, besides the water factor, has an influence on the degree of leaf-aeration; and Prof. Bews has suggested that, since *Portulacaria* and *Avicennia* both have a badly-aerated substratum whereas the other species named have not, the aeration system of the leaf is also influenced by the degree of soil-aeration.

Careful experiments indicate that the supposed difference between sun and shade leaves (of the same species) is really due to an increase in the specific gravity of the leaf-substance of sun leaves as compared with that of shade leaves. All previous workers have expressed their results in terms of the live weight of the leaf, and thus have obtained an apparent increase in the intercellular space content of shade leaves; but when it is expressed in terms of leaf-volume, there is no such increase.

From the ecological viewpoint, the *degree of variation* exhibited by various types has provided some most interesting data. Among the species dealt with, those with the greatest variability in the magnitude of the intercellular space system are species which are pioneers in plant succession (e.g., *Portulacaria afra*, *Gymnosporia buxifolia*, *Combretum spp.*), or else are variable in their ecology (*Ptaeroxylon utile*). Those with a less degree of variability are species confined to later stages in plant succession (e.g., trees in High Veld Bush) or to specialized habitats (e.g., *Piper capense*, *Avicennia officinalis*). The occurrence of such variations in the aeration system of plants is of considerable interest, since it is in the intercellular spaces of the leaves that gaseous exchange between the plant and the atmosphere takes place. The degree of leaf-aeration, therefore, is a factor affecting the three vital functions of transpiration, assimilation, and respiration. *Variations* in so important a factor are of especial significance when viewed in the light of an hypothesis to be suggested in the next paragraph.

The quantitative results given above are valuable in that they illustrate and confirm an important ecological principle which was

first propounded to the writer by Prof. Bews. The principle is that pioneer types are more variable in their physiological structure and functions than subsequent types, and *for that reason* able to adapt themselves to the more varied and more variable conditions presented by the habitat during early stages in plant succession; whereas subsequent and climax types are less variable in physiological structure and functions, and for that reason limited to the stable and often specialized environmental conditions which obtain in the late and final stages of succession.

The work of which the main results are here briefly presented is the first attempt at obtaining precise quantitative confirmation of Dr. Bews' suggestive hypothesis. The results obtained indicate that further work along similar lines—the comparison of the physiology and physiological structure of pioneer species with that of subsequent species in various plant successions—may be expected to provide results of equal importance in either confirming or modifying the original hypothesis.

AGRICULTURAL EXPERIMENT: ITS DESIGN AND INTERPRETATION.

By E. Parish, B.Sc.,
Department of Agriculture.

Read July 15, 1921.

Summary.

1. The variation in yield of single plots similarly treated is so great as to render valueless comparisons made from the result of single plot trials; similarly with experiments with small numbers of animals, owing to the high variation in the individual.

2. Replication in agricultural experiments is absolutely necessary. This should be obtained rather by replication of the plots in a field trial, or animals in a feeding trial, in any year, than by continuing the experiments over a number of years. It is desirable, however, even when the experiments are properly designed, that they be repeated in successive years.

3. In field trials the replication of the plots must be systematic and so designed as to vitiate the effect of progressive differences in the soil. Suggestions for the conduct of manurial and variety trials and co-operative experiments will be made in the full text of this paper.

4. In animal feeding trials the individuals must be carefully selected and be uniform in age, breed, sex and condition, and should be at least five in number in each lot, and preferably 10. The animals in the lots under comparison should be subjected to

uniform conditions for two or three weeks prior to the commencement of the experiment.

5. In field trials no appreciable increase in reliability is gained by enlarging the plots beyond 1-40th of an acre.

6. In interpreting the results of agricultural experiment the "Probable Error" figure is useful, since it is a guide to the reliability and variability of the results under consideration.

THE LIFE-HISTORIES OF SOME TREMATODES OCCURRING IN SOUTH AFRICA.

By ANNIE PORTER, D.Sc.Lond., F.L.S., F.R.S. (S.A.).
Parasitologist, South African Institute for Medical Research, Johannesburg.

Read July 11, 1921.

Abstract.

It is well known that the life-history of a parasitic Trematode may usually be divided into two main phases, one passed in an invertebrate host and the other in a vertebrate. A few Trematoda are known in which two successive invertebrate hosts occur and only one vertebrate host, but such have not been notified in the Union of South Africa. Here the Trematoda whose life-histories are known are digenetic.

In South Africa, as in other parts of the world, the invertebrate hosts of digenetic Trematodes are usually Mollusca. When South African Mollusca are examined for larval Trematoda it is found that a large number of different kinds of the larval forms are present, and in only a very few cases have the adults corresponding to the larval forms been worked out. Conversely, a number of adult Trematoda from various vertebrate hosts have been notified, of whose early developmental stages and invertebrate hosts nothing is known.

It has been my good fortune to have been able to determine the life-histories of several South African flukes during the last three years*, some of which are now summarised, full details being reserved for future publication.

SCHISTOSOMES.

(1) *Schistosoma haematobium.*

Schistosoma haematobium is the fluke responsible for human urinary bilharziasis. The larval stages are passed usually in South Africa in the freshwater snail, *Physopsis africana*, and occasion-

* See Med. Journ. S. Africa, 1920, vol. XV, pp. 128-133; Ibid., vol. XVI, pp. 75, 76; S.A. Journ. of Science, 1920, vol. XVII, pp. 126-130.

ally in the freshwater snail, *Limnaea natalensis*, both of which I have found infected in nature as well as determined experimentally. The life-history of *S. haematobium* in South Africa briefly is as follows:—

The terminal spined eggs pass from the human body with the urine. If they reach water, a ciliated larva or miracidium hatches from each egg and swims about actively. If the pond snail, *Physopsis africana*, or more rarely, *Limnaea natalensis*, is encountered, the miracidia penetrate the pulmonary cavity of the snail, enter the liver and settle down there, losing their motility and developing into hollow structures termed sporocysts. From the walls of the sporocyst buds arise which develop into active forked tailed cercariae, which not only invade other parts of the liver but also reach the generative organs of the snail. The cercaria of *S. haematobium* has a body about 240μ long by 100μ broad, its tail is about 200μ long by 45μ broad, and the caudal forks are about 80μ to 100μ long. There is a small oral sucker and the ventral sucker or acetabulum is also small. Three pairs of mucin glands are present, each capped by a hollow piercing spine and opening on the outer margin of the oral sucker. A group of several large germ cells lies behind the posterior sucker.

The cercariae ultimately leave the snail, swim about in the water, and should they come in contact with the skin of a person bathing or paddling in the water, or even drinking it, they attach themselves to the skin, bore through it, dropping their tails in so doing, reach the bloodvessels, and find their way to the liver and mesentery of the human host. In the branches of the portal and mesenteric veins the worms gradually assume the adult form. Laboratory animals exposed to or drinking water containing cercariae have become infected and have died of bilharziasis, after about two months, adult worms being obtained *post mortem*.

The adults are unisexual, the males being broader and thicker but shorter than the females. The males that I have obtained experimentally have been from 3mm. to 17mm. long. The suckers are near one another, the ventral sucker being the larger and being pedunculated. The surface of the body is beset with cuticular spines. The mouth opens on the anterior sucker, and the two-bulbed oesophagus communicates with the intestine which bifurcates behind the posterior sucker. These caecal forks unite far behind and the gut ends as a single canal of short length. The testes are four in number, rounded and large. The edges of the body are folded to form the characteristic gynaecophoric canal.

The females obtained by me experimentally varied from 5mm. to 30mm. long. They were thread-like, with weak suckers. The ovary is in the posterior half of the body. The uterus is voluminous and usually contains a number of mature terminal spined eggs at one time. The vitellaria lie in the posterior quarter of the body. The female is carried in the gynaecophoric canal of the male. She migrates from the region of the liver and deposits her eggs in the walls of the human bladder, whence they make their way to the cavity of the bladder and pass out with the urine.

(2) *Schistosoma mansoni.*

Schistosoma mansoni, the excitant of bilharzial dysentery, is transmitted in South Africa by at least three molluscs, namely, *Planorbis pfeifferi*, *Physopsis africana*, and *Isidora tropica*. The fluke is not a common parasite of man in the Union of South Africa, but is fairly common in British and Portuguese East Africa and very common in South America. My infected molluscs were obtained in Natal. *Planorbis pfeifferi*, in my opinion, is probably the more common transmitter of *Schistosoma mansoni* in South Africa, and *Isidora tropica* the least common. I have only once so far found Isidora infected with the cercariae of *S. mansoni*, but was able to produce the adult worms in a white rat exposed to these cercariae. Fuller details are set forth in my article (1920) in the "Medical Journal of South Africa," Vol. XVI, p. 75, already cited.

The life-history of *Schistosoma mansoni* is on the same lines as that of *S. haematobium*. The eggs are lateral spined, and are passed with the faeces of an infected person. On reaching water the miracidia emerge from the eggs, swim about, and should they succeed in reaching one of the aforementioned molluscs, enter the pulmonary cavity and reach the liver where they develop into sporocysts that produce cercariae. These cercariae are smaller than those of *S. haematobium*, the body of each being only about 150μ long and 60μ broad, the tail being proportionately smaller. The body contains two pairs of large acidophile mucin glands and four pairs of smaller basophile mucin glands. Each gland opens by a hollow spine at the anterior end of the oral sucker. Numerous small cells constitute the rudiments of the genitalia. These cercariae leave the snail and, if they reach the human body, they develop as with *S. haematobium* in the liver and mesenteric veins and become sexually mature.

The adult male in general structure resembles that of *S. haematobium*, but has eight small testes, while its alimentary canal has forks which unite relatively early, so that the single portion of the intestine is long. The males that I have obtained experimentally were from 3mm. to 11mm. long. The filiform females measured from 4mm. to 14mm. long, had very weak suckers, and presented the same structure of the alimentary canal as the male. The ovary is median, the vitellaria occur in the posterior part of the body, and the uterus usually contains one only of the lateral spined ova at a time. The ova are laid singly in the submucosa of the rectum whither the female migrates after fertilisation, and produce ulceration there. They pass out with the stools of the infected person.

(3) *Preventive Measures.*

Preventive measures against infection with *Schistosoma haematobium* and *S. mansoni* may be briefly summarised. Measures against pollution of soil and especially of water by urine or faeces of infected persons must be instituted. Proper disposal of excrement, preferably by burning, is necessary. Great care is needed

not only with open water used for washing linen or bathing, but with domestic supplies from wells or ponds used for drinking water. Infection takes place by way of both the mouth and the skin. All water from suspected infected sources should be allowed to stand for two days before being used, by which time the cercariae are dead.

Eradication of snails is also desirable. While this is not entirely possible, yet the number of snails can be kept down to a great extent by trimming of banks and by using domestic ducks on open water, for these birds rapidly reduce the snail population, while owing to their domesticated habits they do not fly from pool to pool, bearing snail eggs on their feet as do wild duck. Certain small "millions" fish, such as are used for mosquito control, will also feed on trematode cercariae, and might be employed in dams or bathing pools for the double purpose of mosquito and cercarial destruction.

Distomes.

The life-histories of two common distomes, namely, *Fasciola hepatica*, the European sheep fluke, and *F. gigantica*, the African cattle and sheep fluke, may be outlined.

(1) *Fasciola hepatica*.

The transmitter of *Fasciola hepatica* in Europe is the small snail, *Limnaea truncatula*, as was shown by the magnificent work of Thomas and of Leuckart. I have been able to determine experimentally that two transmitters are present in South Africa, namely, the pond snails, *Isidora tropica* and *Limnaea natalensis*. Sexually mature flukes have been obtained by feeding rabbits and laboratory bred sheep with encysted cercariae from these naturally infected molluscs, while laboratory bred snails have been infected direct by exposure to the miracidia from eggs of *Fasciola hepatica* taken from condemned sheep livers at the Johannesburg Abattoirs. The life-cycle of *F. hepatica* in either *Isidora tropica* or *Limnaea natalensis* is practically the same as that of *F. hepatica* in *Limnaea truncatula* in Europe.

The ovoid, operculate eggs of *F. hepatica* measure 130μ to 145μ long by 70μ to 90μ broad.

The miracidia hatched from the eggs are about 125μ long by 25μ to 30μ broad. They have well marked eyespots. They enter the pulmonary cavity of the snail and penetrate the liver, where they develop into sporocysts varying in my specimens from 500μ to 720μ in long diameter. Within the sporocyst the rediae develop, and these leave the sporocyst when about 35μ long and then grow considerably, some measured being as much as·8mm. long. There is a well-marked collar and a relatively inconspicuous birth pore. Finally, the rediae produce cercariae, which are rounder than those of *F. gigantica*, having highly contractile bodies, measuring from 250μ to 300μ long and 200μ to 225μ broad. The simple tail is about 450μ long. The body has cystogenous granules, but these are not so dense as those of *F. gigantica*. At encystment a resistant

spherical cyst is produced. When ingested by sheep or cattle, the encysted cercaria or agamodistome develops into the adult liver fluke, the structure of which is well known.

(2) *Fasciola gigantica.*

The vertebrate hosts of *Fasciola gigantica* are Ruminants, chiefly cattle, sheep and goats. The invertebrate host I have determined to be the common pond snail, *Limnaea natalensis.* The life-history of *Fasciola gigantica* I described last year (this JOURNAL, 1920, Vol. XVII, pp. 126-130), so that repetition here is unnecessary, but it may be useful to indicate some of the differences between the adults of it and of *F. hepatica.* Thus, *Fasciola gigantica* differs from *F. hepatica* in the following respects:—It has a shorter cephalic cone, almost parallel sides, large acetabulum which is closer to the oral sucker, an alimentary canal in which the direct diverticula off the two main longitudinal stems are more numerous and more backwardly directed than in *F. hepatica,* a less conspicuous and more straggling ovary, and the posterior testis more sharply delimited from the anterior one. The ova of *F. gigantica* (measuring 150μ to 190μ by 75μ to 90μ) are also larger than those of *F. hepatica.*

PARAMPHISTOMES.

Paramphistomum calicophorum.

Owing to difficulties in obtaining literature, full identifications of the Paramphistomes that I have bred in the laboratory cannot be submitted here. The Amphistome herein discussed is probably *Paramphistomum calicophorum* Fischoeder, common in the rumen of cattle in South Africa. The larval stages are passed in the fresh-water snail, *Isidora tropica.*

The parthenita are rediae found in the liver and hermaphrodite gland of *Isidora tropica.* The rediae are muscular and some reached 3mm. in length. The cercariae are conspicuous, each having an oval body measuring 400μ to 500μ long by 300μ to 400μ broad, with a simple tail about as long as the body. Two prominent, black, pigmented areas are present, which surround the true eyes. The mouth and anterior sucker are well-marked, the pharynx distinct. The excretory system consists of two lateral tubes, which have a sinuous course, each bifurcating into two, one on each side of the eye. A bifurcation also occurs just posterior to the branching of the oesophagus, the branches of each side uniting to form a continuous transverse tubule. The genital rudiments consist of two small testicular masses with one ovarian rudiment posterior to them. Cystogenous glands are present.

Encystment occurs on grass or on water plants. The tail is cast, and a mass of cystogenous material is poured out. Some of the pigment granules are also shed. The cystogenous material gradually hardens, and a more or less spherical cyst, varying from 400μ to 550μ in diameter is produced. These cysts fed to laboratory animals developed into the large cherry-pink Amphistomes, which,

when mature, vary from 5mm. to 12mm. long by 4mm. to 5mm. broad, identical with those common in cattle in Johannesburg Abattoir. Many full-grown adults are about 10mm. long and 4mm. broad. The anterior sucker is large; the oesophagus forks, the two branches of the gut passing backwards almost to the large acetabulum or caudal sucker. The two testes are slightly lobulate, one at a slightly lower level and posterior to the other. They are laterally placed and their fields do not overlap. There is a great development of the pars muscularis of the cirrus. The small ovary is posterior to the testes, near the anterior border of the acetabulum. The vitellaria extend forwards almost to the anterior sucker. Numerous ova are produced, which are rather slow in maturing, at any rate under laboratory conditions. If the miracidia reach *Isidora tropica* they enter the snail and the life-cycle of the fluke recommences.

The life-cycles of two other larval Amphistomes are under investigation.

As far as can be ascertained from the literature available this Paramphistome would seem to be *Paramphistomum calicophorum* of Fischoeder, now placed by Stiles and Goldberger (1910) provisionally in their subgenus Cauliorchis. Further work is in progress, and I believe that Mr. C. S. Grobbelaar, of the University of Stellenbosch, is also working on this or an allied species of Amphistome, so that further information is likely to be available. The eyespotted cercaria that I have used I cannot identify with certainty as the *Cercaria frondosa* of Cawston, as that author gave no critical details, while it does not agree in certain respects with *C. frondosa* described by Faust from preserved specimens sent him by Cawston. However, some of the more obvious structural features of the cercaria have already been mentioned by me in the preceding.

Preventive Measures.

Preventive measures against infection of vertebrates by the different species of Fasciola and by Paramphistomum may be summarised. As infection is by way of the mouth in both cases, access to herbage immediately bordering water must be prevented by fencing, and an adequate supply of water that has stood for two days must be provided for cattle and sheep. Any encysted cercariae will be found on the sides of the vessel in which the water has been contained prior to use. Snail infestation of water should also be prevented by the use of domesticated ducks, as mentioned previously in connection with Schistosome infections.

ECHINOSTOMES.

(1) *Echinostomum fulicae*, n. sp.

The adult Echinostome, for which I suggest the name *Echinostomum fulicae*, was found in the alimentary tract of the redknobbed coot, *Fulica cristata*. The larval stages are passed in either of the snails, *Tomisia ventricosa* or *Isidora tropica*, as I have determined experimentally.

The sporocysts are small, thin and colourless. Many of those seen were about 200μ to 300μ long, and 90μ to 150μ wide. They are nonmotile, but when cercariae are present and writhing about within, the sporocyst moves backwards and forwards. The cercariae seem to mature two at a time and emerge from any part of the sporocyst. It is noteworthy that, in the majority of Echinostomes, the cercariae are produced from rediae. So far, in the relatively small amount of material at my disposal I have not found rediae and only small numbers of sporocysts.

The cercariae are very active and simple tailed. The anterior pharyngeal region is protrusible. The acetabulum is large and active. The posterior end of the body is prolonged downwards laterally forming small caudal pockets around the tail, which organ narrows somewhat abruptly and then swells out near the end, producing a pegtop-like appearance. The excretory tubule is fairly straight in the tail, but dilates somewhat in the "pegtop" area.

Encystment occurs, both in the liver of the snail itself, on the edge of the mantle and on the outside shell of the snail. The cysts are from 125μ to 150 in diameter. The cyst wall is thick, transparent and firm. The body of the agamodistome when fully developed is beset with cuticular spines, and two rows of large spines are on the collar which is set on a collar ridge. Rudiments of the genitalia are more obvious than in the unencysted cercariae.

The adult flukes measure from 5mm. to 10mm. long, their breadth varying from 1·5mm. to 2mm. The anterior or oral sucker is fairly large, the acetabulum large, conical and powerful. The pharynx is muscular and often is thrust through the mouth during active movements. The oesophagus is of medium length, branching into two intestinal caeca immediately above the acetabulum. The ovary is simple, there is a large shell gland, and the coiled uterus is usually crowded with brownish ova. Numerous small vitelline glands are present near the margin of the body, extending from the posterior end of the body to the rim of the acetabulum, the transverse duct sloping slightly anteriorly before uniting with the shell gland. The testes are two in number, one immediately behind the other. The posterior testis is expanded somewhat and in some specimens appears somewhat trilobed. A large excretory vesicle is present.

For purposes of reference the name *Echinostomum fulicae* with characters outlined in the preceding is proposed for this fluke. As far as I can ascertain, after consulting such Echinostome literature as the monograph of Odhner (1910), the fluke herein briefly described does not agree in morphology with any of those with which I have been able to compare it.

(2) *Echinostomum xenopi.*

The life-history of this fluke is set forth in my paper in the "Medical Journal of South Africa," Vol. XV, pp. 128-133, and need be only briefly outlined here. The larval flukes are parasites of *Physopsis africana*. The rediae vary greatly in size, but many are about 1·5mm. long. They contain orange chromatophores and

have a large intestine frequently with black contents. The cercariae have a body length of about 450μ and breadth of 150μ. The tail is usually about 350μ long. The head armature consists of two alternating rows of spines with a group of four spines at each lateral extremity of the head. Two germinal rudiments are present. The excretory system consists of a polygonal laterally compressed bladder from which two sinuous collecting tubules pass forwards. The body is crowded with cystogenous granules which largely obscure the finer details of the excretory system.

When the cercariae leave the snail they are easily visible to the naked eye. Should they reach a "clawed toad or frog," *Xenopus laevis*, they pierce the skin, cast their tails, extrude cystogenous granules, and encyst beneath the skin. After an interval the Echinostomes leave the cysts, find their way outwards, and crawl about on the surface of the body. It is possible that they may undergo still further development in a second vertebrate host.

Monostomes.

The parthenita of a Monostome fluke were found by me in the liver of *Physopsis africana*, and exhibited together with the young adult forms in 1919. (See "Medical Journal of South Africa," Dec., 1919, pp. 117-8.) The parasite is rare. By experiment the "clawed frog," *Xenopus laevis*, was shown to be its vertebrate host.

The redia is about 1·5mm. long, and is noticeable as having no marked locomotor appendages, but the body is muscular and contractile. The pharynx is oval and the intestine a simple sac. The cercaria has a well-marked but small oral sucker, but the acetabulum is absent. The excretory bladder is posterior and two collecting tubules pass forwards, uniting near the sucker. The oesophagus is very narrow, and the caecal intestinal forks at first are close together but diverge more posteriorly. Large numbers of unicellular cystogenous glands are present. The cercariae after leaving the snail swim about actively for a short time. They do not live long in water. Should they reach *Xenopus laevis* they penetrate the skin, especially round the eyes and at the glandular areas along the lateral lines, and encyst beneath it. Occasionally some cercariae penetrate deeply and encyst in the muscular tissue, and in one case, in the kidney substance. The cysts are usually about 0·5mm. in diameter. After a time rupture of the cyst occurs, and a small, actively moving Monostome, as yet somewhat imperfectly developed sexually, emerges and reaches the surface of the skin in some cases and in others wanders in the subcutaneous and peritoneal cavities. Further work is needed on this organism and some is in progress.

In conclusion, it cannot be too strongly emphasised that work on the Trematoda is long and tedious. It necessitates study of the detailed morphology of larval forms and correlation of the same with adult structures, as well as experimental work on the life-cycles with both the vertebrate and the invertebrate hosts.

SOME PARASITIC PROTOZOA FOUND IN SOUTH AFRICA: IV.

By H. B. Fantham, M.A.Cantab., D.Sc.Lond.,
Professor of Zoology, University of the Witwatersrand, Johannesburg.

Read July 15, 1921.

Abstract.

The present paper records and summarises my work on parasitic Protozoa since the last meeting of the Association. My previous results have been communicated to this Association at the last three meetings and are published in this Journal, Vol. XV, pp. 337-338, Vol. XVI, pp. 185-191, and Vol. XVII, pp. 131-135. This account provides an extension of our knowledge of the distribution of the parasitic Protozoa in South Africa.

As before, the term "parasitic" is used in a wide and general sense, and may include saprozoic and commensal organisms, as well as coprozoic forms.

One of the most interesting organisms has been *Cycloposthium bipalmatum*, which shows periodic variation in numbers in the infected horses, and appears to be associated with intestinal disorders of the character popularly described as "colic." Attention may also be drawn to a new species of *Entamœba* in the horse and to the new species of *Giardia*—in the ox and in the horse—recorded herein.

The measurements of organisms given in this paper are determined from camera lucida drawings of the organisms made at various known magnifications.

Sarcodina.

Entamoeba intestinalis has been observed on rare occasions in the colon of horses as reported by me previously. I have since found it in the caecum of the horses in very small numbers.

I have also been able to observe what I believe is a new Entamoeba in the faeces of two horses showing signs of intestinal malaise. One of the two horses also harboured *Cycloposthium*. The Entamoeba was present in small numbers. It has much the appearance of *Entamoeba histolytica* of man, except that it is rather larger and possesses an oval instead of a rounded nucleus. There is a structure usually called a karyosome with a centriole in the nucleus. Like *E. histolytica* it can and does ingest red blood corpuscles. The trophozoites were variable in size, but fully extended ones measured 40μ to 50μ by 23μ to 29μ, while rounded ones measured 28μ to 35μ. The rounded, thin-walled cyst sometimes contained chromatoid bars and four nuclei were present in the

mature cyst. The diameter of cysts measured was 15μ, 20μ, and 24μ. I propose the name *Entamoeba equi* for this parasite, with the species differentiation as stated in this paragraph.

A vervet monkey, *Cercopithecus lalandii*, had a small amoeba of the *Entamoeba coli* type present in the encysted condition in its faeces. The cysts contained eight nuclei and were rather rare. They are possibly to be identified with those of *Entamoeba legeri* of Mathis*, 1913. The cysts were 17μ to 18μ in diameter.

Another Entamoeba, probably *E. bovis* of Liebetanz, has been observed in extremely small numbers in the rumen of an ox. One extended trophozoite was large and measured 50μ by 70μ.

Mastigophora.

The Mastigophora recorded previously by me have been seen again. In addition, the following Flagellates may be recorded for the first time in South Africa.

A *Bodo*, possibly a new species, was observed in the rumen and reticulum of oxen and sheep in Johannesburg. It possesses a kinetic nucleus or parabasal body, and on that account would formerly have been placed in the genus *Prowazekia*. Rounded, oval, conical and sausage-shaped forms occurred. The active elongate forms were 10μ to 15μ by 5μ to 6μ. The rounded forms were about 8μ in diameter and cysts measured 7μ to 8μ by 5μ. For purposes of reference this organism may receive a new specific name and be called *Bodo ruminantium*, though it may turn out to be a coprozoic form. A *Bodo* was recorded by me last year from the rumen of sheep.

A *Trichomonas* has been observed very rarely and in very small numbers in the intestine and faeces of two horses. A fresh specimen outlined with the camera lucida measured 11μ by 6μ. This form, for the purpose of distinctive reference, may receive a new specific name and be called *Trichomonas equi*.

Large rounded uni- and bi-flagellates, apparently large specimens of the *Monas communis* described by Braune† (1913), which probably includes the *Sphaeromonas communis* var. *maxima* and *minima* of Liebetanz, were found by me in the rumen and reticulum of sheep in Johannesburg. They measured 14μ to 17μ in diameter of body. The flagellates are active, and the uniflagellate forms often have the flagellum wrapped round the body, and when it uncoils a jerky movement results. The biflagellate forms are in process of fission. Monads of similar size occur in the ox in the same situations.

Two apparently new forms of *Giardia* (*Lamblia*) have been found by me in my examinations of *post-mortem* material, namely, one in the rumen and duodenum of an ox and another in the large colon of a horse. The animals died in the districts of Johannesburg and Pretoria respectively. The parasites were extremely few in number in each case, and observations on them were limited

* Bull. Soc. Med. Chirurg. Indo Chine, IV, pp. 388-410.
† Arch. f. Protistenkunde, XXXII, pp. 111-170.

to the fresh state, as it was impossible to secure good, permanent preparations with such a small quantity of material as occurs in these very sparse infections. As far as I know, from the literature at my disposal, *Giardia* have not been found in these hosts before, and so, for purposes of reference, it seems well to give them new specific names, though later they may be found to belong to species already known. Doflein in his "Protozoenkunde" states that Giardia occurs in sheep. Particulars, so far as available, of these two new rare Giardia are as follows:—

Firstly, the Giardia occurring in the rumen and duodenum of the ox, which I shall call *Giardia bovis*, gave body measurements in its trophic form of 23μ by 13μ, while a cyst measured 11·5μ by 7μ, taking long and short diameters in camera lucida drawings in each case.

Secondly, the Giardia found in the large colon of the horse, which I name *Giardia equi*, gave measurements, correspondingly taken, of 20μ by 10μ for the flagellate stage.

The interesting Proflagellate, *Selenomastix ruminantium*, which I recorded from goats last year, has now been found in the rumen and reticulum of a sheep examined by me in Johannesburg but coming from the Middelburg District, Cape Province.

Sporozoa.

Eimeria faurei was found by me in the intestines and faeces of two sheep examined in Johannesburg. Gametocytes were observed in the mucosa of the small intestine and the caecum, while oöcysts were present in the faeces. An oöcyst measured was 33μ long by 23μ broad.

A Leucocytogregarine has been observed in leucocytes of the mononuclear type in a smear of the heart-blood of a reedbuck, *Redunca* (*Cervicapra*) *arundinum*, for which preparation I have pleasure in thanking Dr. Hertig, who made the smear for me in Barotseland.

An interesting *Leucocytozoon* has been observed in the leucocytes of a bird known as Burchell's coucal, *Centropus burchelli*, killed near Pietermaritzburg. I have much pleasure in thanking Dr. E. M. Robinson for the preparations. The infected leucocytes showed displacement of their nuclei and the ends of the cells were slightly drawn out into short processes in some cases, though when large parasites were present—and these were the most common—the processes or "tails" of the host cells were not obvious. The trophozoites were elongate, measuring about 13·3μ by 5·3μ. The microgametocytes had pale staining cytoplasm but a rather large nucleus. They vary in size from 7·3μ to 13·3μ in length by 4·6μ to 9μ in breadth. The macrogametocytes had densely granular cytoplasm and stained deeply. They are 12μ to 14μ long and 9·3μ to 10μ broad. Both macrogametocytes and microgametocytes may have a certain amount of extra-nuclear chromatoid substance. Schizogony occurs in the lungs and some apparent schizonts have been seen in a smear of the peripheral blood. Free schizonts in a lung smear measured 11μ by 10·6μ. Schizonts showing nuclear

division into four have been seen. The final stages of schizogony have not been observed with certainty. Apparently the only ecto-parasite known to occur on Burchell's coucal belongs to the Mallophaga, and is said to be a new species of *Degeeriella*. A smear preparation, stated to be of this bird-louse, has been found to contain in the gut curious structures like partly digested avian red blood corpuscles and peculiar sporozoite-like bodies. However, it is generally considered that Mallophaga do not suck blood, and definite conclusions regarding the transmission of the Leucocytozoon are not permissible on the material available. I propose a new specific name *centropi* for this parasite, and so designate it *Leucocytozoon centropi*, with the specific characters stated in the foregoing. The bird was also infected with Halteridium, but that parasite is not likely to be spread by lice, as Halteridia are usually transmitted by flies.

Piroplasma caballi has been seen in the blood of a mule in the Transvaal.

Sarcocystis tenella. The work on the seasonal periodicity of Sarcosporidia (*S. tenella*) in sheep has been continued. Unfortunately, fewer animals were available than last year, and I was not able to make observations during December, 1920, to March, 1921, owing to absence in England. However, my results, taken weekly as far as possible on fresh *post-mortem* material, show that in 1921 the spores of *Sarcocystis tenella* were very few in number or in some cases absent in the heart-muscle (apex of the ventricle) of sheep in the Pretoria district in the cold months of June, July and August, but—extending my observations to the date of publication of this paper at the end of 1921—show an increase in numbers in September and in December. It should be noted that in Johannesburg no rain was officially recorded during the three winter months mentioned, showing that the season was slightly drier than in 1919 and in 1920, and the average temperature during that period was lower than in 1919 or 1920. It is also of interest to mention that, in mid-summer, young Miescher's tubes may be found in scrapings of fresh heart-muscle after massage of the organ.

Sarcosporidia have also been seen in the heart-muscle of cattle, the species being *Sarcocystis blanchardi*, while *S. moulei* was seen in the heart of goats, *S. bertrami* in the heart-muscle of horses and *S. miescheriana* in that of pigs in the Transvaal.

In the heart-smears of a reedbuck, *Redunca* (*Cervicapra*) *arundinum*, shot by Dr. Hertig in Barotseland, I have found spores of a Sarcocystis.

Infusoria.

All the Ciliata previously recorded by me have been seen again. In addition, periodicity has been studied in *Cycloposthium*, and a few other ciliates have been observed in domestic animals in South Africa for the first time. These results may now be stated.

Cycloposthium bipalmatum Fiorentini has been observed in two horses in some detail over a period of four months, and general

observations are being continued. The horses suffered from intestinal disorder commonly called "colic," and at times of evacuation of large numbers of the ciliates the horses suffered greatly from flatulence and passed much gas. The numbers of *Cycloposthium* in a measured quantity of faecal ooze were counted daily. Liquid ooze was obtained by pressing a quantity of freshly shed manure. The ooze, being too thick for counting parasites, was diluted. One part of ooze, thoroughly mixed with four parts of sterile water, has usually proved suitable. The counts of *Cycloposthium* were obtained in each case by using one-fifth c.c. of ooze thus diluted, made into fresh thin preparations under coverslips, the organisms being counted with the aid of an Ehrlich ocular. For the period May 1 to June 13, 1921, the daily numbers ascertained were 164, 85, 50, 40, 11, 0, 0, 3, 8, 22, 35, 55, 194, 217, 136, 133, 82, 15, 5, 0, 5, 18, 5, 3, 3, 0, 0, 342, 284, 1116, 724, 515, 309, 112, 67, 12, 0, 0, 16, 126, 114, 157, 194, 317. The three successive maximal periods were of 14, 16 and 14 days respectively. Counts over other periods gave similar results and the average periodicity of maximal crops of *Cycloposthium* was about 14 days. Coincident with the increase in the number of the ciliates there was an increase in the softness and pulpiness of the faeces of the horses. When the number of ciliates was very low or zero, the faeces were formed and hard. As the number increased, the faeces became softer and looser until at periods of maximum crops of ciliates the faeces were practically diarrhoeic in character. Other horses kept and fed under identical conditions showed no symptoms, nor did they harbour *Cycloposthium*. In one case a horse became infected and was very "colicky." *Cycloposthium* was found and the source of infection traced to a dirty stable broom used in the infected stable.

Referring to my remarks in previous communications (1919, 1920) regarding Balantidia in pigs, it is of interest to state that during 1921 of the large intestines of 33 pigs examined in Johannesburg 14 were found to be infected with *Balantidium coli*. The caecum and the rectum were the sites of infection observed. In the caecum active motile forms of the ciliate were found, while in the rectum both motile forms and cysts were seen. Red blood corpuscles were observed inside the motile ciliate Balantidia from three of the pigs. In two of these the Balantidia which had ingested red blood corpuscles were present in the caecum, and in the third pig the Balantidia containing red blood corpuscles were present in the caecum and in the rectum. Further, in the case of one of the pigs in which motile ciliates were present in the caecum, a "pin-point" ulcer was found in the wall of the caecum. The relation of *Balantidium coli* to the pig is usually considered to be that of a commensal, but should it reach man it is less in harmony with its host, and changes or is forced to change its mode of life by ingesting more red blood corpuscles and working its way into the host's gut-wall, and so it becomes pathogenic in man.

Paraisotricha colpoidea Fiorentini was seen in relatively few numbers in the fresh caecum of one horse that had died from horse sickness virus at Onderstepoort.

Didesmis ovalis Fiorentini was found in the large colon of two horses examined *post mortem* at Onderstepoort. This *Didesmis* appears to be rare.

Blepharoprosthium pireum Bundle was found in very small numbers in the caecum and large colon of a horse examined *post mortem* at Onderstepoort.

Blepharocodon appendiculatus Bundle was observed in the freshly shed faeces of a horse in Johannesburg. The numbers of the ciliates were very few. A specimen drawn with a camera lucida was found to be larger than the dimensions given by Bundle* (1895), its long diameter being 55μ compared with an average of 35μ as stated by Bundle.

Blepharosphaera intestinalis Bundle was seen in the large colon of a horse examined immediately after death at Onderstepoort. It appears to be rare.

A species of *Blepharocorys* hitherto unrecorded in South Africa, namely, *B. jubata* Bundle, was found in small numbers in the freshly shed faeces of a horse in Johannesburg. A specimen outlined with a camera lucida measured 49μ by 26μ, which was larger than the measurements given by Bundle.

Triadinium caudatum Fiorentini was seen once again in the large colon of a horse examined *post mortem* at Onderstepoort. The same horse contained the *Giardia equi* mentioned previously.

Entodinium caudatum Stein, as figured by Schuberg† (1888), was seen in the rumen of a sheep examined in Johannesburg. The organisms were active but few in number. They undergo distortion at death, the caudal process often breaking off.

Spirochaetae.

Spirochaetes are here recorded for the first time in South Africa from two Gastropod hosts, namely, the freshwater snails, *Limnaea natalensis* and *Physopsis africana.* Spirochaetes have seldom been recorded from Gastropods. The Protistan organisms occur in the livers or digestive glands of the snails and are of the *Spirochaeta balbianii* type, with blunt ends. Those observed were slow-moving and each possessed a spirally wound membrane or crest. When stained they showed a diffuse nucleus of chromatin bars. The organisms were long, some of them reaching 200μ in length. As regards degree of infection, it may be stated that only seven spirochaetes were seen in a *Limnaea natalensis*, which also harboured young encysted flukes.

Spirochaetes much smaller in size were found in relatively small numbers in the reticulum of sheep examined in Johannesburg. They had pointed ends. A long form measured 30μ, while two shorter forms measured 10μ and 13μ respectively in length, and may have been recent products of transverse division.

* Zeitschr f. wiss. Zoologie, LX, pp. 284-350.
† Zool. Jahrb., III., Abt. f. Syst., p.p. 365-418.

I have pleasure in thanking the Director and Officers of the Veterinary Research Laboratory at Onderstepoort and Mr. Kirkpatrick, of the Johannesburg Abattoirs, for material. I also wish to thank the Research Grant Board for a grant towards the expenses incurred in these investigations.

A NOTE ON *ORTALIA PALLENS* MULS.

By R. H. T. P. Harris,
Department of Entomology, Durban.

Read July 13, 1921.

In December, 1919, while searching for Coccidae in the Botanic Gardens, Durban, a cluster of what appeared to be mealy bugs was noticed at the base of a fig tree (*Ficus natalensis*). The insects at first appeared to be attended by numbers of *Pheidole punctulata*, Meyr., an ant very common in and around Durban. A closer examination, however, disclosed the fact that these insects were catching ants in their mandibles, and that they were Coccinellid larvae densely clothed with tufts and filaments of white secretion.

Many of these larvae have been collected in this neighbourhood since, either beneath the bark of old logs or below sheets of iron which have been for some time undisturbed, or amongst old rubbish under a tree where the ants had formed a colony. They are usually clustered at the entrance of an ant burrow or in its vicinity, or under some cover below which the ants are numerous.

An ant on approaching a larva will stop and examine it, stroking the filaments with its antennae. Then, if the ant proceeds to make a closer examination, the head of the larva is suddenly raised, the ant seized in the powerful mandibles, and its body juices rapidly sucked out, after the manner of an ant lion. When an ant investigates the insect from the rear, the cerci are raised and moved to and fro, the anal protuberances then giving the appearance of a mouth and palpi. Frequently this causes the ant to retire; but sometimes it will tug viciously at the tufts of hair on the sur-anal plate but without in any way injuring the larva. In many cases the larva has been observed to double up its body, so bringing the attacking ant within reach of its jaws, which speedily puts an end to the matter. The larva, after casting aside the empty body of the ant, retracts its head, and applies its flattened body once more to the surface on which it is resting, ready to seize the next inquisitive ant coming within its reach.

The larvae, though capable of fairly rapid movement when disturbed, spend most of their time clustered in one spot, and do not hunt for food, evidently relying on the ants' natural inquisi-

tiveness or some attractive aroma to bring prey within their reach.

The writer is unable to give any account of the habits of the adult beetles or to indicate where the eggs are deposited by the females. It was only with considerable difficulty that five adults were raised from fifty larvae and pupae collected in 1919-1920, the remainder being parasitised by a large Chalcid.

The larvae are usually found clustered in groups and covered by waxy filaments. After each moult the larva is naked, but becomes reclothed within 24 hours. Four larvae, carefully denuded of all covering with a sable brush, and placed in a tube one afternoon, were found to be clothed by the morning with short filaments. The newly moulted larva is of a pale yellow colour. At the back of the head, and laterad on each segment are knob-like glandular areas, from which tufts of filaments are produced, whilst on the rest of the dorsal surface a fluffy secretion is formed. At the time of pupation this fluffy secretion is produced in sufficient quantity to envelope the pupa, which then appears to be wrapped in the finest cotton wool. This envelope, being readily adherent to anything that touches it, protects the pupa from attacking ants, which are frequently found dead, entangled in the fluff. The larval exuvium can be found beneath the fluffy covering attached to the anal end of the pupa.

The few adults which were reared were tried with many species of the common Coccidae, Aphidae, and also *Pheidole punctulata*, but they refused all food in captivity. When tried with living *Pheidole* a viscous yellow fluid was exuded from the femoro-tibial joints of the beetles, which, coming in contact with the ants, caused them to fight and tear one another to pieces. This experiment was repeated three or four times with the same result.

The adult beetle, when alive, has pubescent elytra of a light dove-grey colour, a black head and clypeus, large azure blue eyes, and legs and thorax of an ochraceous yellow. The body below is yellow, with pygidium exposed. The colours rapidly fade after death, the whole insect often assuming a more or less uniform yellow colour, a striking contrast to the living beetle.

I am indebted to Mr. Claude Fuller, Assistant Chief of the Division of Entomology, for the following information:—

"*Ortalia pallens* Muls. is represented in the collection of the Division of Entomology at Pretoria by specimens from Kwambonombi, Zululand, and in the Transvaal Museum by material from Durban, Pietersburg, and Lijdenburg. The Zululand specimens were determined by Dr. G. K. Marshall, of the Imperial Bureau of Entomology, those in the Transvaal Museum by Dr. Weise, of Germany."

In connection with the specimens mentioned as coming from Zululand it is interesting to note that they were taken from a fluffy white mass found in the centre of a red ants' nest, collected by Miss M. Wilde Brown and forwarded to the Division by the Curator of the Durban Museum. At the time no suspicion was aroused as to the real significance of the presence of these Coccinellids in the ants' nest.

AN EDUCATIONAL EXPERIMENT.

By H. S. Keigwin, M.A.,
Director of Native Development, Southern Rhodesia.

Read July 15, 1921.

In giving an account of an educational experiment in Southern Rhodesia it is necessary first to give some brief references to the conditions under which the Natives live. First in importance is the system of Native Reserves. These were most carefully examined and reported on by an Imperial Commission, which enquired exhaustively into the subject during the years 1914-15. This has resulted in the permanent assignment of over 20 million acres, or more than one-fifth of the country, for the exclusive use of the Natives. The present Native population is about three-quarters of a million, so that there is an allowance to-day of 26 acres per head, supposing that every Native moved into the Reserves. A man with a wife and two children would have over a hundred acres. But little more than half are in the Reserves, the remainder being on farms, mission holdings, and unalienated land. As European occupation becomes closer, and as Native-owned herds increase, these Reserves will have to accommodate more and more Natives. It is for this reason that we wish to instruct them how to farm better, and to build sounder and more sanitary homes. That indeed is the keynote of our educational experiment. The Native must be taught intensive cultivation, trained to stay in one place, and to get his food by better methods. He is a child of the soil, and it will be for his and for our good if he can be kept there. He may go out to work, but his home must be mainly in the country.

The Rhodesian Natives, particularly the Matabele, are becoming rich in stock. Whereas our first count in 1902 showed that they had 55,155 head of cattle, 60,569 sheep, 197,477 goats, last year's figures show 744,402 cattle, 307,575 sheep, 741,805 goats, a notable increase under European rule. But for all this wealth they are singularly ignorant of how to treat it. Their stock is often badly inbred and stunted. Their laziness is apparent in their keeping their cattle shut up till late in the day, their herding is inefficient and without much thought for their beasts, their kraaling is of the poorest, while such an idea as feeding their stock in bad times is quite unknown. With them it is quantity, not quality, that is desired. I give these few facts so that some idea may be formed of the backwardness of this people. As a Native Commissioner, constantly moving about among the people for many years, the conviction was more and more borne in on me that we must do something for them in their homes. It seemed an indictment on our civilisation that we should know of this state of affairs, and do nothing to remedy it. And yet there are people who say, "Leave them to develop on their own lines, and in their own way."

It seems to me such a course is as impossible as it is unwise. Fortunately there were those in high places who thought so too. Our present Administrator goes everywhere and holds meetings of Natives. He has seen things for himself, and he has supported all sound endeavours to bring about an improvement. Our Native Department has helped in many ways; the missionaries have sought to uplift and inspire. But until recent years there has been no special organisation to co-ordinate these efforts, and to direct a definite policy. In 1918 a recommendation was made that the Government should appoint a Director of Native Development. This was acted upon, and after my long leave in England, during which I spent some time investigating the simpler types of industries, and conferring with men of experience in native administration and industrial development in different parts of the world, I was appointed to my present position. On request I wrote a report on my investigations, embodying therein my recommendations, and this after being presented to the Legislative Council was used as the basis of the experiment.

The root idea of the scheme was that an attempt should be made to get at the people in the mass in their homes, and endeavour to lift them little by little, and as much as possible all together. It was felt that though after a time the higher education which can be given at Institutions may be needed, the foundations should be laid right down among the simple home conditions. The home buildings need improving, the crude agriculture needs instruction, the simple village handicrafts need examination, and, if found worth it, encouragement. It was felt that the Government should identify itself more directly in the uplift of the people. It would mean slow, and for a time unproductive work. Only Government could afford to take the pecuniary risk that the long view involves, but because of its educational and political value it should undertake it. If the mind of the people could be stirred, and if the general standard could be raised gradually, there might be expected not only great physical progress, but such an improved mental consciousness that the people would not bo so easy a prey for the educated agitator. Racial friction might be lessened, and because of their occupation the people might be kept from discontent, and become interested in their home life.

It must be remembered that we are concerned with a people that is as yet largely untouched. They live for the most part in a more or less communal way in the Reserves. They have been given large areas of land for their exclusive occupation. They can, if they know how, develop their own communities and institutions, where in time, and as they show themselves fitted, they may be given a measure of local government, thus affording scope for those more ambitious spirits that in the outer world might be a source of trouble. But they must first be taught to put their land to better use. We must see to it that before the position becomes too difficult they, and their children, are put into the way of using this land to good advantage, are shown how by their industry they

may better their own lot, and produce something that may be of use to the country.

As he is to-day the Native has little need for continuous work. It is not with him as with us. He probably sees nothing wrong in his way of living. But we surely without any hypocrisy must feel it our duty to help him to realise some better ideal. At the same time frankly we want his co-operation in the establishment of a prosperous community. If we put before him a simple form of industrial improvement beginning at the bottom, springing from those home industries which are already familiar to him, and lifting him gradually through stages that are not beyond his assimilation, we shall teach him gradually to feel and appreciate the advantages of better conditions, and by so doing foster a free and reasonable inclination to go out into the world of labour, and, because it brings him the means to provide himself with the comforts that he has learned to desire, to contribute his share to the enterprise of the body politic. I emphasise this point, because I feel that the critic, who has an uncomfortable fear that if he lends his support to such a policy, fine and fair-minded as he may acknowledge it to be, he will be imperilling both his and the country's labour supply, should feel assured that our policy far from decreasing the supply of labour, should actually increase it, both in quantity and efficiency.

Our plan, then, is to stimulate effort among the people, to put purpose into their lives, and to develop simple industries, particularly those that do not offer direct competition with Europeans. We hope, while improving the home life, to rescue and develop some of the home crafts, and by this means to bring into use the latent wealth of raw materials, which the country undoubtedly possesses. The list of occupations in which instruction will be given is as follows:—(1) Building. (2) Agriculture. (3) Stock. (4) Rope and Mat-making. (5) Basketry and Chair work. (6) Pottery and Tiles. (7) Carpentry and Furniture. (8) Smithing and Wagon repairing. (9) Medicine. All of these should be regarded from the point of view of their value in the uplift of the people, rather than in any sense of vocationalism. They are not the end in themselves, but rather means to an end.

Let me give some suggestions under the several heads.

1. *Building.*—In order to wean the people from their present insanitary and uninspiring home conditions we would teach them some improved type of construction, that, while conforming to the tests for sanitation and hygiene, shall not be too much removed from their conception, nor too hard, nor too expensive, for them to attempt. It is felt that one of the reasons why the Native does not reproduce the better things he sees in large schools, and in employment, is because the difference is often too great for him to see any relation between them and his home possibilities. The type of construction known as Pisé-de-terre seems eminently suited for the purpose. The only equipment needed is a few planks, some bolts, and some sticks to ram the earth with. Most soils, with sometimes a little mixing to give binding, or reduce fattiness, are suitable, so that the bulk of the material can be

dug out quite close to the site. Little, if any, water is needed. The house is strong and durable, cool in hot weather, warm in cold. The door and window frames can be made of local timber, as also the roof. This needs some instruction, which would be given at the Government schools or by demonstrators. By its longer life such a house would strike the first blow at the nomadic tendency of the Native, and incline him to a more settled life. If suitable stone is handy, it is a great improvement to put in a foundation. Good pisé work is practically impervious to ants, and with good projecting eaves the walls will stand sound through the heaviest rains. Where possible the inside should be washed with lime.

2. *Agriculture.*—In Rhodesia Natives are very apt to waste large tracts of land, planting uneconomically, reaping sparse crops, and impoverishing the soil. They lop off the branches of large trees, heap them round the stems, and burn them to get the potash. After two or three years they abandon the ground, and proceed to a new spot, where they repeat the process, and so on till they have exhausted the countryside. Though they have taken to ploughs of late years, the result has not been altogether for good. They rarely, if ever, stump the land, never cross plough, and usually skim over a larger area than they can properly cultivate. Here then is the second need for instruction. To enable the best use to be made of the land for the greatest number better methods of cultivation, manuring, and rotation must be introduced. Besides giving the Native means of growing more and better food-stuffs, it should be possible for him in time to produce crops which will add to the products of the country, and to increase his own purchasing power. So considerable a producer as the Native might become cannot be omitted from the calculations of those who seek to build up the position of the country in the markets of the world. There are many crops which need that very hand labour which a man and his family could furnish, and which multiplied throughout the Reserves might make possible a crop which a European farmer could not attempt.

There is one important branch, concerned with boring for water. The Native Department now has its own plant, with Europeans working it, but with Natives being trained at the school to take over the completed holes, and supervise the pumping. In some of the large Reserves, where increased supplies of water are needed, it is both difficult and expensive to carry out such work by contract. As it is a work that will be going on for years, and as each well needs attention, it will readily be understood what a useful function the centrally placed school has to perform.

3. *Stock.*—I have quoted figures which show that the native is becoming a considerable stock-owner. He has found a good market in selling to Europeans, many of whom have built up their herds on native stock. But the type is often poor, inbred, good neither for milking nor for beef. The country cannot afford to have its grazing used up by unprofitable beasts. We have been trying to introduce better bulls, and to emphasise quality as

against quantity. We wish to improve their handling of their stock. The Native is a haphazard pastoralist. He keeps his cattle late in the kraal, herds badly, is ignorant of treatment, never thinks of feeding. He has learnt the value of dipping. We must now teach him to build his own dips, and to manage them properly. The majority of them never use the milk, and if they do, fail to keep it clean. We were weaning him from his habit of cutting up the hide with the meat. The drop in hides has given us a set-back, but in normal times there should be money in them, and they might under instruction be put to considerable use among the people. The same considerations affect in similar ways his other stock, sheep, goats, pigs, and poultry, and their proper care should be his business when at home.

4. *Rope and Mat Making.*—There is a wealth of fibres in Rhodesia that is practically untouched. The Native knows and uses in his small way many of them, and from the work he does already it seems certain that with instruction and organisation a profitable industry could be started. Where so many fibre concerns find such great difficulty and expense that commercial undertakings are impracticable it is quite likely that a number of Native units, each operating on a small scale, and in different localities, but organised from a centre, might find material and water enough to treat the fibre, and at the centres, or even in the homes, make them up into useful articles. If this industry can be developed, it will both help the Natives, and have its influence on lowering the cost of living to us all. There would probably be needed instruction in the use of rope walks and looms of a simple type.

5. *Basketry and Chair-making.*—Much that is produced by our Natives, particularly their split-bamboo work, is of excellent workmanship and practical utility. By increasing their skill in certain directions, and by adapting some of their present methods to European requirements, we might be able to build up yet another useful and profitable home industry. Conditions of the work in the country should be more healthy and less expensive than in factories, while the raw material can often be gathered and prepared in the home vicinity. With the introduction of osiers the craft might be extended to chairmaking, thus reducing the cost of an article which up country is for most people almost prohibitive.

6. *Pottery and Tiles.*—Judging from the success in Nigeria of the engagement by the Government of a master potter from England, it should be possible here also to teach the use of the wheel, glazing and proper firing. Suitable clays are said to be found in Rhodesia, kaolin, for instance, has been identified in more than one district, and with instruction in their proper preparation the Natives should soon be able to make a practical start with vessels for their own use. With increasing skill they might well be able to supply many of those vessels which to-day cost the Europeans so much to import. It is hoped also that tiles for various purposes could be made, and it should in time become possible to

introduce an alternative for the unsightly and uncomfortable iron roofing so prevalent to-day.

7. *Carpentry.*—Starting with simple instruction to meet their own needs the teaching of carpentry should be a great factor in improving the home and in stimulating the imagination. By learning to make their own door and window frames, and later the doors and windows also, and by constructing sound well-pitched roofs, the people will be bringing health into their homes, and as they get on to furniture there should be born in them a desire for better conditions, which should bring about a higher ideal of life with its greater comforts and efficiency. As a trade they might take to the making of good plain furniture from some of our beautiful native woods, much in the way that the village craftsmen of centuries ago did to such perfection in England. It is interesting to note that some of the chiefs petitioned the Administrator for some such practical instruction to be given their sons instead of only the literary teaching of the classroom.

8. *Smithing and Wagon Repairing.*—With the increasing use of ploughs and carts there has arisen the need for knowledge in repair work. How often can one see a plough or a cart lying idle because some part has broken, and there was no one to repair it. It is usually too far and too expensive to send to the nearest European smithy, and so the thing goes from bad to worse, till it is quite beyond repair. There is need for one or more such repair shops in each of the Reserves. The timely care for implements would have a wider lesson for the people, and should have a bearing on the general question of attention and thrift.

9. *Medicine.*—To anyone who has administered a native territory the need for medical assistance has been ever pressing. Though most districts have district surgeons, these practitioners find their hands full with work among the Europeans, and those Natives who are near at hand. It is only in very serious cases that their services can be requisitioned, and then at considerable expense. During the influenza epidemic of 1918 I was in charge of a district of some sixteen thousand square miles in extent. The lack of some provision and of some simple medical knowledge in the remote Reserves was brought home in a way that I trust may never be seen again. There is no question but that we must try and bring into those native communities some system, however simple, of affording medical assistance. It is impossible to get European doctors, even if the funds could be found. It must be by some system which can be worked by the Natives themselves, backed and supplemented, we hope, by the medical profession, that we shall tackle this necessity. At our Government schools we intend to give a simple training in first-aid, and in the treatment of the more common and less serious ailments. We are at this moment building a hospital at Chindamora, and a well-qualified matron has been engaged. The Medical Director has approved of the scheme, and is advising us. It is hoped to be able to arrange for lectures and advice by the district surgeon, who will also have the general direction of the course to be followed. Besides looking

after the pupils of the school, the hospital will be available for patients from the Reserve, so that it is felt that those men and women who are willing to enter for instruction will have opportunities of practical experience. As the scheme comes to develop it is hoped to be able to open small native hospitals in suitable centres in every Reserve, in direct touch with the nearest magistracy by a main road, so that on the entry of a patient a message may be sent at once to the nearest district surgeon, who will be able to proceed by car with a minimum loss of time. Instead of, as to-day, finding his patient perhaps in the last state of collapse, under a rude shelter of leaves, with the flies at his wounds, the doctor would be able to find him quiet in bed, with his wounds washed and bandaged, and in a state where medical skill may have some hope of success. For the hundred and one simple matters which require no great skill, but just common-sense treatment, it is hoped these men and women who have been trained in our schools will have sufficient knowledge to do all that is required. By some such means as this we hope to be able to obviate much of the suffering and loss of life that occurs in the Reserves.

These then are some of the directions in which the energy of the Native, awakened and instructed, might be employed. As I have said, the motive should be first the good of the Native. It is a fair demand to make of those who have had the advantage of civilisation. It is also, from the point of view of that civilisation, only common-sense to see to it that the great majority of inferior people shall not be left either to stagnate in inefficiency, or on the other hand to get for themselves, in perhaps a dangerous way, that which they are bound eventually to have. There is, moreover, the comforting assurance that this timely assistance will both redound to the credit, and result in the profit, of those who proffer it. With a better informed, more active, more contented community there will be more steady, more efficient, more willing work. With greater producing power there will be greater earning power, and consequently greater spending power.

But, it will be asked, how is all this to be brought about? Our Government has sought a way. It has decided that there is room, over and above the splendid work that is being done by so many of the missions, for a simple form of education, or development, starting from the immediate needs of the people. It has brought into being a system that takes as its base the native home and its requirements. Whatever may be said in favour of the institutional system of education, it is clear that in its essence it relies largely on a traditional system which was evolved for a different people, in a different climate, and for a different set of conditions. Every effort is made to adapt that system to local needs, nowhere with more realisation of its inherent unsuitability than here in Natal. But we are making our Rhodesian experiment in the belief that if we start from the home as our base, and from there work outward and upward throughout the people, we may hope for an uplift that will be more general, and because of its simplicity more helpful to the whole community.

The Government authorised the establishment of an Industrial and Farm School in the Chindamora Reserve, at a spot 20 miles from Salisbury. This was started last year, and will serve the Mashona people. This year a second school has been started in the Gwaii Reserve, some 70 miles from Bulawayo, which will serve the Matabele people. In each case a piece of ground is chosen which is typical of that on which most of the people live. Starting with simple shelters of poles and grass the pupils are required to erect, under instruction, all their own buildings, simple in form, of pisé-de-terre, and of local material throughout. Every pupil during some period of his course, which is of at least a year, and may be two or three, receives instruction and has practice in this work of building. They get out the stone for foundations, dig the soil for the pisé, and fell the trees for the woodwork. Frames and roofs are plainly, but properly, constructed by them. Good thatching is taught. The finished buildings present a sound and pleasing appearance, and they are a slight, but important, advance on the native type. They are easily kept clean, are well lighted and ventilated. If the material is good, and if it is well rammed, we find that white ants do not work in the walls. The floors are also of pisé, smeared, and the boys sleep on mats, not beds. Simple furniture is made. But the whole thing is kept as near as possible to Native ideas with just those important improvements that are necessary, so that these may be within the region of possible reproduction by the Native at home. There is a skilled European instructor in charge of this work, and he gives simple talks on it twice a week, and does his best to see that everyone understands the process. Everything is done by the pupils themselves, and every care is taken to see that they thoroughly understand the meaning of the various operations.

Then there is the agricultural side, also under a European instructor, who manages the farm. Here, again, all the work is done by the pupils, but along educational lines and with constant instruction. Native crops are grown, and only such implements as Natives can afford are used. Lessons are given in the management of oxen—it is a mistake to think that the Native knows all about this already—and in proper methods of ploughing. Lands must be carefully stumped and cleared, and then all the successive stages of ploughing, harrowing, cross-ploughing, planting and cultivating are taught and practised. The value of manuring and rotation of crops is illustrated by parallel experiments, and records are kept, but all on simple lines, and within the Native's power of understanding and doing. Though it is not practicable for all to be at work on farming at one and the same time, it is arranged that everyone shall have some practice at it during his course, and the lectures are given to the whole school. It should be mentioned that our pupils are almost all strong, well-grown boys, not children. Besides the common lands there are individual plots of 60 x 60 feet, where every pupil can be made solely responsible for the cultivation of his own plot. They are laid out in long parallel lines, with a road down between, where the manure cart can manoeuvre,

and the instructor pass in supervision, and all are worked in accordance with the instruction given. The point is that the success or failure rests with the individual. From the plots a good indication may be derived of the character of the pupils. They all put in an hour a day, except at certain seasons, on these plots. In the wet season the ordinary kraal crops, such as mealies and beans, are grown, and in the dry season green vegetables, which have to be watered. Irrigation is not possible. Prizes are given each term for the best worked plots. Immense keenness is shown, and boys often run off at odd times to give a touch to their plots. It is hoped that when they see that from their own efforts greater yields have been got from smaller areas, and those areas by rotation and manuring have been in constant cultivation, these boys will have assimilated lessons which will bear fruit when they return to their kraals. I should mention that in all our field work we have the advantage of the advice and assistance of the experts of the Agricultural Department.

Under the guidance of Mr. Henkel, formerly Forestry Expert in Natal, and now happily in charge of our Forestry Department, we have instituted a course in tree planting. Pupils are informed of the value of afforestation, and are taken through the various stages of planting the seeds, transplanting the seedlings, and taking care of the trees in their growth. Owing to so much of our wood being soft timber, and subject to borers, this course will be of great value to the people in their home requirements.

It is hoped, as the farm grows, to include systematic instruction in other branches of farming operations. But first we seek to give the Native knowledge and practical experience of what he ought to be able to do in his home, both in improving his house and its surroundings, and in the growing of his food. Though direct vocationalism is not contemplated, but rather an all-round training of a simple and useful nature, it is hoped to fit Natives to perform the more responsible duties in European employment, so that we may train a supply of drivers, dairy hands, poultrymen, thatchers, gardeners, and the like. I hope and believe that our training, with our discipline, will so stabilise the character, and increase the efficiency, of those that pass through our hands that they will be welcomed by those employers who value good and reliable workmen, and are prepared to give them good treatment and remuneration.

Side by side with all this industrial activity, which for five days a week occupies seven hours a day, there is given a sound literary education. The curriculum may not be strictly orthodox in the eyes of the schoolman, but it aims at widening the Native's horizon, informing him of values, building on his natural aptitudes, and drawing out his capabilities. The educated Native must be of greater value than the uneducated, provided his education has been on right lines. For the mass the time for literary preoccupation has not yet come. It is well that they should learn that education is not incompatible with work, but rather a help and a preparation for better work. Our pupils have one and a

half hours' school work in the early morning, and the same period again at night. Their reading is made as practical as possible, while their arithmetic is directed chiefly to the actual needs of daily life. Cleanliness and punctuality are insisted on, and an effort is made towards the formation of good habits.

Other industries have been mentioned as of probable value in stirring these people into effort. For these it is hoped to make use of the Government schools as experimenting centres, where with qualified instructors, and the necessary equipment, investigations may be made into raw materials and into the Native workmanship of the various crafts. It may be that we shall attract to these schools some of the best craftsmen, and so develop their craft, that they will either settle near by, and help to form the nucleus of an industrial village, or go back to their people able and willing to act as leaders and instructors in the craft among the kraals. Many of these things must wait over. We must proceed slowly, consolidating every step. But the purport of the scheme is there, and each development but waits the opportunity. As already stated, we are erecting at the present moment a hospital for Chindamora. We shall have a trained matron in residence, and the plan has the support of the Medical Director. We hope to begin by training a few hospital orderlies and nurses. Besides the care of the pupils there will be work among the people of the Reserve, so that opportunities of practical experience should not be lacking. This branch of the work will be expanded as opportunity offers, till all Reserves are provided with men and women of simple but sound training to take charge of small hospitals for the relief of their people. For the time being this is the only direction in which women are being provided for, but the importance of lifting them at the same time as the men will not be lost sight of. This is a branch of the work which can best be undertaken by the missionaries, whose co-operation is being sought throughout the whole scheme.

We do not require any academic qualification for admission to these schools. Our people are for the most part illiterate, and we feel we cannot wait on literary attainment. Many of our best pupils so far are boys of very humble education. We hope to turn out men of character and purpose. Practical knowledge is surely of greater value to the mass than academic proficiency. At the same time we do not refuse them literary training, but we seek a safe combination of the two. Some of the missions have sent us promising pupils to get a training in building and so forth. We hope to receive an ever-increasing number of such pupils, and we look forward to close co-operation with the missionaries. From the best of our pupils we hope to get men who will go back to their people and take up work under the Government in the Reserves, showing the people what they have learned, making their own homes and lands an example, and demonstrating to as many as they can reach these better methods. By this means the benefits of the scheme should be brought within the reach of all, and the work of uplift should influence the farthest kraal. From time to

time we would visit these demonstrators, and encourage them in their work. We would call the people together, and by word and deed bring them to see the advantages to be gained by an effort to improve. By shows and competitions we would introduce a spirit of emulation, and stir up their interest, till each of these places became the centre of life and uplift for the locality. I hope that, where to-day there is encountered apathy and superstitious conservatism, there will in time be found keenness and freedom for progress: that where to-day the suspicious and reactionary chief or headman forbids all innovation, in time those very men, or their successors, will be in the forefront of the march towards progress and improvement. The power of such men must not be despised. In Native life it is a very real force. It cannot be coerced. But by steady and persistent instruction, illuminated by successful undertakings encouraged by the Government, their hostility may be changed to friendliness, and their opposition to support. It is only by carrying out this experiment among them, in the conditions to which they are accustomed, and with the materials with which they are familiar, that such improvement can be brought about; and it is only by direct Government participation and encouragement that the mass of the people can be touched.

BANTU INDUSTRIES.

By D. A. Hunter,
Lovedale, C.P.

Read July 11, 1921.

Bartholomew Diaz discovered South Africa in 1486, six years before Christopher Columbus discovered America. The Netherlands East India Company took possession of Table Bay and occupied the adjacent lands in 1652, thirty-two years after the Pilgrim Fathers landed at Plymouth, Massachusetts. No doubt many factors have contributed to cause the tremendous disparity in the advance made by the United States as compared with that made by South Africa in approximately the same time. To trace these factors would be an interesting and enlightening historical study. That one of them has been South Africa's backwardness in industrial development can hardly be gainsaid.

Imagine any great civilised country with practically all its more important industries eliminated except farming and mining: idleness and poverty would quickly assert themselves and national bankruptcy and decadence would be hard on their heels. To-day post-war Europe can furnish more than one practical proof of this.

A country's population is its most valuable asset. Without population the country is dead: land, minerals, and fisheries alone are valueless. It was said in pre-war days that the production of a working man in England added £200 a year in wealth to the State. If, however, the working man is idle, instead of a benefit to the State, he becomes a burden upon it. It follows that a large idle or semi-idle population in any State means not only an immense annual loss in potential wealth but also a serious drain upon its resources. The idle man consumes more than he produces.

There can be no doubt that by far the greatest undeveloped asset South Africa possesses is its native population. Within the Union there are approximately 5,000,000 Bantu. Reckoning that, including men and women and boys and girls above school age, 2,000,000 of these are potential workers, and that they might under proper organisation and training produce half the annual wealth attributed to the white labourer, we have a possible annual increase to the wealth of the State of £200,000,000.

But the material wealth of the State is only one, and not the main, consideration. A prosperous, progressive, and contented population is of far greater moment than great wealth, and it is quite as necessary to work for the prosperity, progress and contentment of the Bantu people as of the whites; for South Africa's whole economic fabric is founded and built up upon the labour of the Natives. Were they as a race to strike, and stop work, South Africa would indeed be in an unhappy plight.

Now it concerns us to discover if present conditions are conducive to the contentment of the Natives. To-day there are some 250,000 Native and coloured boys and girls in the schools of the Union. This means that the wants of these young people in clothes, food, houses, books, and in numerous other things will, as they grow up, be increased. Is anything adequate being done, either in school or out of it, to fit these young people to earn honestly such a living as will enable them to meet these increasing wants both for themselves and their children?

I am well aware that a great many whites are totally opposed to educating the Natives. These wise people overlook the fact that every white person who employs a Native—be he or she farmer, miner, storekeeper, manufacturer, contractor, or housewife—is already educating that Native, and arousing in him the wish to obtain many things in the way of food, clothes, houses, implements, and others too numerous to mention, of which he sees the white man in possession, and which become desirable in his eyes.

There are only two ways in which Native education can be effectively stopped. The one is absolute segregation which would end both native trade and native labour; the other that white people leave the country altogether.

South Africa is not prepared for either of these alternatives, so native education, on a scale far beyond the capacity of the schools, will go on inevitably and increasingly. One thing the often-times disparaged missionaries try to do, is to impart, together with the inevitable education, moral and religious sanctions which may serve as ballast where the tremendous impact of modern civilisation threatens to prove a fiercer squall than the Native can withstand.

It will be at once said that there is plenty of work to be had on the mines and on the farms. While this statement seems at first sight true, on examination it will be seen that it requires much modification before it can be accepted as even a partial answer to the problem. The mines afford temporary work to a considerable number of men; but the conditions at the mines are such as to preclude a Native making the work of a miner his life calling. All the time he spends at the mines he is an exile from his family and his home. Hence he only takes up mining as a temporary job, and returns home as soon as his pressing wants are supplied.

This means that many thousands of native men are being trained to work only spasmodically instead of learning to do regular work all the year round. It also results in perhaps two or three being at home while one is at the mines. They may not be absolutely idle, for there is something to be done on the land or among the stock; but they acquire the habit of working intermittently, with many idle intervals, and far below their potential capacity.

A far more serious charge against the present system of work on the mines has been brought recently by Dr. R. A. Reith

Fraser, Medical Inspector for Venereal Disease for the Union. In a recent lecture, according to the report in the "Cape Times," he said:—

> "He wondered why the treatment of syphilis among natives as a vital business proposition had not yet appealed to the big labour magnates of this country. Syphilis was steadily depleting the labour market of South Africa, and with such rapidity and certainty that in twenty years it would, if not stemmed, render coloured labour so rare that only the very wealthy would be able to pay for it. He dealt with the unnatural lives of the 300,000 natives on the Rand through the absence of their wives, and said it was up to the Chamber of Mines to reorganise the living conditions of the industrial native, so that he might bring his wife and family, and be able to lead a domestic life on the mines. He offered this solution to the industrial authorities, as the Chamber of Mines was of opinion that such a gigantic scheme was impracticable. An alternative policy would be short service contracts for the native, rigid medical examination on arrival and departure, and exhaustive treatment for such as became infected. Women admitted on the industrial areas would have to be rigidly dealt with."

If this considered opinion of a scientifically trained expert be a true setting forth of the facts the most valuable asset within the Union is being squandered so recklessly that within twenty years, under present conditions, it will be exhausted.

Farm labour offers but little attraction to a Native who has any ambition to improve his position or that of his children after him. It is said to be a custom among certain European farmers in the Cape Province to pay a Native whole-time manservant 10/- a month (i.e., £6 a year), together with a dish of mealies once a week and some sour milk. How can a man in these days clothe himself, his wife and his family on 10/- a month and supply their other wants besides? How can he send his children to school when there is probably no school for miles round? Such conditions are only fit for "red" Kafirs at the blanket stage. I believe farmers would be much better served were they to offer terms of employment that would attract the more advanced Natives. If farmers would also give their Native employees a small share in the profits of the farm, so that it would be to the interest of the latter that all the farming operations should be as successful as possible, I believe it would pay them handsomely. This has already been tried with marked success.

After the mines and farms and other outlets for native labour have been supplied there remains in the kraals a vast quantity of potential labour unemployed. This may be seen any day in passing through the kraals scattered over the districts chiefly inhabited by Natives. The old adage is true that Satan finds plenty of mischief for these idle hands. Far happier would they be, and better too, could they be trained to regular work, from Monday morning till Saturday at noon. Such training would go far towards the making of more reliable character. Moreover, the regular income to be obtained from steady work would relieve the poverty which has pressed so sorely upon many of the native

people in recent years. Successive bad seasons and excessively high prices have reduced many of them to the verge of starvation, in consequence of which scores of men, women and children have, at one hospital in the Eastern Province of the Cape, been found to be suffering from scurvy. Is it small wonder that there has been muttering and discontent? Unless speedy relief is brought to them many will be driven from their homes to find work in the towns. This would be a calamity of the first order for South Africa. Natives deteriorate rapidly under the conditions of town life, both morally and physically. To allow a steady migration of the Bantu to our large towns is to create in these a native submerged tenth which will before long offer an immensely difficult problem. A thousand times rather anticipate the somewhat hopeless cry of "Back to the land" by giving those who have not yet left it such conditions as will induce them to remain where they are.

That this can be done has been proved by practical experience in the United States. The late Dr. Frissell, of Hampton, Virginia, whose name is much honoured in America, wrote that wonderful things had been done by means of demonstration farms. Whole communities of coloured folk who had been anxious to abandon their country homes and move to the cities were, through the application of scientific principles to agriculture, enabled to double and sometimes quadruple their crops. Better homes, roads, schools and churches were thus made possible, and a measure of contentment was restored.

The policy of segregating the races has found favour with many thoughtful people as the line along which the most hopeful solution of our great native problem lies. Enforced segregation is at the stage we have already reached impracticable. The hands of time's clock cannot be turned back. But voluntary segregation is both possible and practicable. Improve the conditions of life in the native areas and the Natives will wish to remain in them. Young men may want to go out for a time and work; but the Native has a great love for his home. To him, be it never so humble, there's no place like home, and he will be glad to return and settle down on the land if that be made reasonably possible to him.

It will be agreed that there is a great and urgent work to be done in setting every available member of the Bantu race within the Union to useful productive work suited to his capacity and environment. In this direction Rhodesia has progressed further than the Union, for a very capable and energetic man, a Cambridge graduate, has been appointed as Director of Native Development.

There are three main lines along which it seems that industrial development should be undertaken.

The first is agriculture. It would have been thought that a live Department of Agriculture blessed with even a small degree of vision would have seized upon the immense possibilities of agricultural expansion latent in our native population. They are

born agriculturalists and stock farmers, but their methods are of the crudest and most antiquated. This is their misfortune rather than their fault, for no one has in a practical way shown them better methods, except in a few isolated instances. The results from these isolated instances are proof of the immense possibilities of expanded production and increased stock, which will bring much wealth to the country as soon as the people are helped wisely and sympathetically, and shown how to do things in the best way.

Probably the Department of Agriculture is too set in its methods to be able to undertake the work that is immediately needed. Besides, where white and native interests clash the latter will invariably suffer. It seems necessary, therefore, to duplicate the Department of Agriculture in such measure as will give into the hands of a distinct branch of that Department the development of native farming.

The Bunga's agricultural college at Tsolo should be duplicated in various suitable centres in the Union. In addition to this there should be small experimental demonstration farms in native areas, worked on simple lines suited to native farmers, where they may see for themselves what to do, what better methods can accomplish, and also where they can count upon good advice and encouragement.

Later, when the native agricultural colleges are turning out qualified men, some of the ablest of them might be put in charge of the proposed demonstration farms under a white superintendent who might, perhaps, be able thus to supervise a whole province and so keep down expense. Along this line the food production within the Union could be increased enormously; the Natives would be better off and consequently more contented; and the traders would prosper and through them the whole trade of the country would increase in volume.

Native farming on the pastoral side needs similar guidance and stimulation. The introduction of stud animals at the demonstration farms would soon improve the grade of cattle, sheep and goats. If a good strain of milking goats were gradually to replace the nondescript herds now in possession, that alone would greatly benefit native children who are, in their tender years, often permanently injured for lack of milk. Small native children are from time to time brought to the Victoria Hospital at Lovedale as emaciated as the worst to be found in famine-stricken Austria or in a famine area in India. Enquiry generally proves that there has been an entire lack of milk in such cases. Attention should be given to poultry farming, bee keeping, and fruit and vegetable gardening. Along these lines the possibility of increased production is unlimited. These industries could be carried on at the demonstration farms in a simple and inexpensive way suited to native conditions, and the farm manager could help the people to dispose of their surplus produce to the best advantage.

Fencing must be encouraged and subsidised. The amount of unnecessary and unproductive labour wasted on herding because of the absence of fences is almost incalculable. Again, if the natives

were taught and encouraged to plant timber trees, the beautiful, but treeless Transkei, to mention only one part of the country, might be greatly enriched and transformed, droughts would almost certainly be modified, shelter for stock would be provided, and the often difficult problem of fuel would be overcome. Let me state, in passing, that if natives were trained along the lines indicated they would become much more efficient as farm assistants and would be well worth a higher wage. The native who could graft and bud and set out an orchard, prune and harvest fruit, keep the vegetable garden in good order, look after poultry and bees and help with the stock, all in an intelligent and up-to-date method, would be a treasure any farmer would be glad to get and keep.

In native village life agricultural and pastoral work do not give occupation to all the members of a family, nor do they as a rule give whole-time occupation to any of them, unless it be the herd boys whom it is proposed to release for more productive work by the introduction of fencing. The problem, then, is to find other work which will keep the natives usefully employed, and this introduces the subject of village industries. Such primitive industries as the Natives had before the advent of the white man —smelting, weaving, pottery—have almost, if not altogether, disappeared before the articles imported from overseas. This has been a great loss in native life and it needs to be replaced. How can this be done to the best advantage? In India, Ceylon, China, and Japan a very large proportion of the population lives in villages. In these numberless villages industries have been carried on for countless generations and have been brought by long experience to considerable perfection with a minimum in the way of outlay on plant and tools. If South Africa wishes to save an immense amount of time and much money in experimenting, by taking advantage of the experience ripened through many generations in eastern village life, let her send a commissioner to the East to see what is being done there, and to arrange to graft on to native village life in South Africa what seems suitable and possible.

The Commissioner would require to know our natives and be familiar with the raw products of this land. He would also require to be a man with some experience in, and aptitude and enthusiasm for, industrial work, so that he might bring a discriminating judgment to aid his observations.

It would seem wise and reasonable to give the Natives as far as is practicable industries which will be peculiarly their own, such industries as can be carried on in their villages without bringing them into direct economic competition with white people. Wicker furniture and basket-making do not require the accurate measurements and angles of carpentry, and many Natives already possess some aptitude for this work. Some years ago, from enquiry made in Grahamstown, I came to the conclusion that the stores in that one town alone were carrying about £1,000 worth of wickerwork stock, practically all of which was imported from Madeira. Osiers

grow freely in this country. It should not be difficult to transplant the industry as well as the willows. Our beautiful grasses, bayonet reeds, and the like lend themselves to basket-making, mat-making, etc., and the leaves of a palm growing near the coast make excellent hats. Why not try to found a South African "Panama" hat industry? Rope and string can also be made from our raw products.

An intelligent commissioner visiting India, Ceylon, Burmah, the Malay States, the Philippines, China and Japan would be able to select many more village industries which would bear transplanting to this land. He might also be able to arrange for instructors of those industries selected to come to South Africa for a limited period, and teach picked Natives who could in turn become the instructors of their own people. This should be much less expensive than employing European instructors, and would be less likely to give to the learners an inflated idea of the monetary value of their work.

It would probably be necessary to establish one or two schools of village industries, and native teachers might be required to spend a year, or less, learning one or other of these village industries. After a reasonable time it should be imperative that every native school teach one or more handicrafts suitable to the raw material of the district in which the school is situated. In this way, within a single generation, a tremendous advance in village handicrafts might be achieved.

Beyond village industries in the ordinary sense of the term there is a further industrial development for which some of the more advanced native communities appear to be ripe. Many natives are now capable of doing skilled labour. Were they allowed to do it, their earnings would be considerably increased. If the white man denies to them the right to do skilled labour in the towns and on the mines, he cannot deny that they shall do it in their own homes to supply the needs of their own people. To give to the Natives in their own parts of the country suitable and remunerative employment should, as we have already indicated, result increasingly in a voluntary segregation such as is calculated to obviate or reduce the clash between white and coloured labour, and at the same time greatly to benefit the native by keeping him away from the degrading influences of town life, while also making it unnecessary to break into his family life by long absences from home.

The tendency of the age is for profit sharing—that the man who by his hand-toil wins the wealth should receive a fair share of that wealth. This has been in large measure conceded to the white man. Is it right to deny it to the Native?

I venture to suggest that a limited liability company (let us call it Bantu Industries, Ltd.) be floated by men of goodwill, who wish to see South African industries go ahead on the basis of fair dealing with the Bantu, and that this company start approved industries for Natives in selected areas, which the population and other conditions indicate as suitable. One essential

would be sufficient capital to carry the venture through its early years until successful production is arrived at. If, say, £50,000 was subscribed, it might be called up as required. The interest should be limited to, say, 7½ per cent., and any profits beyond that figure divided into two equal parts, the one-half going to a development fund, the other as a bonus to those native employés who had worked steadily throughout the year. Provision should be made in the articles of association to prevent any capitalist buying up a controlling share in the company when it has reached a paying stage, by making it incumbent upon any shareholder to give the company the first offer of any shares he desires to sell at the lowest price he is willing to accept, and by limiting the holding and voting power of any individual to, say, one-tenth of the subscribed capital, or in any more effectual way that can be devised.

Various industries suggest themselves with which to make a beginning. Perhaps that of spinning and weaving might be tried first. Wool from native-owned sheep through the Eastern Province and native territories could be purchased and made into blankets, and the blankets sold to the natives. As things are now, a native has to pay many profits on the wool grown on his own sheep before it comes back to him as blankets—if he ever gets back as good as he sends away. There are the profits of the trader, the coast merchant, overseas freight, brokerage, and railway freight from, say, Southampton to Bradford. The wages for spinning and weaving might be retained and spent in South Africa instead of overseas. And another series of profits and freights have to be added to the manufactured article before the native sheep owner can carry a blanket from the trader's store to his hut.

It is practically certain that the locally-made article would have more genuine wool in it than most of the blankets a native can now afford to buy from a trader.

Once blanket making were successfully established—and that this can be done in South Africa has no longer to be proved—a further step might be taken by starting to make tweed, and a clothing factory would naturally follow to make the tweed into clothes for natives. Here again unnecessary profits would be eliminated, wages would be paid and spent in this country instead of overseas, and the natives would no longer be condemned to wear the cast-off clothes of Europe, as so many of them have to do to-day.

European merchants and traders need not be alarmed at such proposals. Their trade would greatly increase because with regular wages the natives would have more money to spend on the numerous articles they could buy only from the stores.

A further development might be that of tanning—tanning the hides and skins from native-owned cattle and sheep. A boot and shoe factory might follow, also harness and saddlery manufacturing, and the making of other leather goods such as hand bags, kit-bags, valises, and such like.

That such proposals are not impracticable may be deduced from hard facts. For instance, on the West Coast of Africa the Basel Mission started industries for the natives within its sphere of influence. These industries, which have since the War been taken over by the Commonwealth Trust, Ltd., of London, were before the War paying a profit of something like £20,000 a year to the funds of the Missionary Society. Besides its missions on the West Coast, the Basel Missionary Society had work on the Malabar Coast in South-West India, where a similar policy of starting weaving to help the natives was initiated at Mangalore as long ago as 1744. The material named "calico" is said to be called after the town of Calicut, on the Malabar Coast. This peculiar cotton cloth was first woven there. Seven years later Mr. Haller, a trained specialist in weaving, was sent out from Germany. He, on arrival at Mangalore, introduced the first hand-loom with the fly shuttle. Along with the weaving, dyeing work was also started, and the khaki dye which is now so widely used is said to have been first invented by Mr. Haller. He endeavoured to prepare a dye for hunting suits which would approximate to the natural colour of the soil and would not be conspicuous from a distance. The one which he prepared out of the rind of the cashew-nut tree (*Anacardium occidentale*) and of the extract of the heartwood of the catechu tree (*Acacia catechu*), both of these trees being common in his district, answered the purpose and was called khaki, from the Hindustani *khak*, meaning ashes, dust. The "Madras Mail" stated:—

> "When Mr. Haller first brought out his khaki, the then Superintendent of Police in Mangalore was so pleased with it that he got permission to introduce it for the use of the police force under him. Lord Roberts, when he was Commander-in-Chief in India, once paid a visit to the Mangalore weaving establishment, and it was then that he happened to see khaki which he afterwards recommended for the use of the British soldiers."

Likewise, the shikari cloth, which is now popular, was first introduced by this weaving establishment, the colour having been designed by Mr. Webster, hence the material is called "Webster's Shikari." Most of the European sportsmen and officials of the Government Forest Department have availed themselves of the cloths of the mission weaving establishment to supply their regular clothing needs. Encouraged by the success of weaving in Mangalore, weaving establishments were established in other mission stations on the West Coast, such as Cannanore and Calicut, with increased improvements in various departments. This industry affords regular employment to hundreds of Indians.

Another industry developed to a remarkable degree by the Basel Mission in India is that of tile making. If this could be developed on a considerable scale in South Africa, so that tiles became as cheap or cheaper than corrugated iron, we might hope to deliver ourselves from the wrong many of us do our families and ourselves by living under an iron roof so absolutely unsuited to this country of great variations in temperature.

The first tile factory was started at Jeppoo, Mangalore, in the year 1665. The handpresses and mills driven by bullocks were replaced by machines worked by steam-power in the year 1881, when the first steam-engine was set up at Mangalore. The tiles manufactured there having been found of immense use to the public and to the Government, the latter, as a mark of its appreciation, issued an order to their Public Works Department to use mission tiles for all public buildings. The Government further evidenced their appreciation by giving, as an encouragement of this industry, a considerable quantity of firewood gratis from their forests, and it is gratifying to note that the Government is still encouraging the manufacture of these tiles, because of their superior merits. At first, only flat roofing tiles were made. Now, at Jeppoo, near Mangalore, the pioneer tile factory in India, flat roofing tiles, ridge tiles, both plain and ornamental, sky-lights and ventilators, ridge and hip terminals, and finials of various kinds, grooved spire tiles, hanging wall tiles, ceiling tiles of many different designs, hourdis or ceiling slabs, common and ornamental clay flooring tiles, Victoria cement flooring tiles, well and chimney bricks, salt-glazed stone and earthenware drainage pipes, terra-cotta vases, flower-pots, architectural terra-cotta ware, etc., are made in artistic styles. They are considered a boon by architects and builders. A word may also be added here about the ceiling tiles which have been found to be of great value, especially in towns where timber is rare and expensive. When these first appeared on the market appreciation was expressed by the public, and high praise was given them in the leading newspapers, such as the "Madras Mail" and "Hindu." Similar praise was bestowed on the hourdis or ceiling slabs which are now being used instead of wooden ceilings in storeyed houses with remarkable success The advantages of these are numerous, namely, there is perfect resistance to heat, exclusion of noise from storey to storey, water-tightness, strength and durability. There are buildings that exhibit the technical skill of the clay manufacturers of these tile works in many large towns of the Indian Empire and of Ceylon. Such artistic works were made in one single factory at Jeppoo, where this manufacture was started with about twelve men. Now it gives employment to three hundred and thirty persons, and twelve to fourteen thousand tiles are turned out daily.

The second tile factory was started at Calicut, in the year 1873, similar to the one at Jeppoo, with hand presses, bullock mills, etc. Gradually the work developed and steam-engines were installed. Now the factory has two hundred and twelve hands engaged in its operation, the daily output being about twelve thousand tiles of various kinds, such as flat roofing tiles, flooring tiles, ceiling hourdis, ridges, etc. There was an increasing demand for the products of this factory, and as there was also an increase of converts in the Christian Churches on the West Coast who were seeking employment, it was deemed necessary to start new factories in other mission stations as well.

Accordingly in the year 1882 a factory was started at Kudroli, a suburb of Mangalore, where now three hundred and eighty-eight

people are working, the output being about five million tiles a year. Another factory, at Malpe, near Udipi, was started in the year 1886; the fifth at Codacal, near Edakulam, where two hundred and eighty-five people are working; the sixth at Palghat, where two hundred and forty persons are now working, and in the year 1905 the seventh factory was established at Ferok, about seven miles from Calicut, where two hundred and thirty-three persons are engaged in tile making. All these seven factories are equipped with up-to-date machinery and are conducted under expert European engineers. All works are carried on under factory rules and regulations, and the factories are periodically visited and inspected by Government officials, such as factory inspectors, sanitary and medical officers, and the district magistrates. The products of these seven factories are sold throughout the Indian Empire, Burma, and Ceylon, and are also exported to foreign countries. In British East Africa the railway buildings on the Uganda Railway from Mombasa to Port Florence, the railway terminus at the Lake, are all covered with mission roofing tiles. In Tanganyika Territory, Basel Mission tiles were also being stocked at different places. Tiles are also exported to Aden, and to Basra on the Persian Gulf at the mouth of the Euphrates. They are also being exported in rather large quantities to the Straits Settlements, to Sumatra, British Borneo, and even to Australia. So it is evident that these tiles have won a wide reputation. They have been shown in many exhibitions in India, such as those held in Madras, Bombay, Cawnpore, Allahabad and Benares, and more than a dozen gold and silver medals were awarded them at these exhibitions.

I have dealt at some length with these successful enterprises because they present accomplished facts, and because I believe that what has been done in India can be done in Africa to the great advantage of whites and natives alike.

The problem is to make a start, and it seems very difficult to get a start made. A certain unvoiced and indefinable, but nevertheless very real, opposition appears to emanate from high, or official, quarters. One of my reasons for arriving at this conclusion is that it seems to be the considered policy of the "South African Journal of Industries" to exclude from its pages any reference to the development of native industries. Even the Advisory Board of Industry and Science is apparently powerless to change this policy, for I have been informed that it decided at one of its meetings in Johannesburg some considerable time ago that a paper was to be inserted in that Journal on Native Industries, but that decision has evidently been turned down, for the paper in question has not yet appeared.

Is this a wise or a safe attitude at this time of day? Let me pass on to you the words of one who knows the Native and the Transkeian Territories as few know them. He says:—

"(1) The people as a whole are far poorer than they were in 1890.

(2) They are spending far more than they did then.

(3) They are far more deeply in debt than they were then.
Now what does this all end in? Just this:—
(1) Rapidly increasing poverty and debt.
(2) A hopeless outlook to the future.
(3) Growing discontent with the present.
(4) Restlessness and a blind desire for change.
(5) An evergrowing liability to be misled by rash and evil-minded agitators.

To these agitators—some ignorant, half-educated young bloods, others adventurers of experience bent on raising money for deputations and petitions—it is very easy to make out that "All these evils come on us because white men treat us ill and flourish by seeking our blood." Because it is true that in very many quarters there is a mind obsessed or diseased, half-scared, half-angry, ready to strike out blindly at the first thing that seems to injure.

"Hence come these recurring Native troubles. Sitting on the boiler by increasing the police will not help for long.

"The pressing question is, How is life to be made less dreary, aimless and futile for the rapidly growing mass of Natives who have got past the stage when plenty of mealies, a good deal of beer, an occasional faction fight, with endless loafing and gossip around the kraals, spell content and happiness? How, in a word, are these people to get something to occupy their minds and energy, and give them an ambition and a prospect in life?"

Happily, a new factor has come into South African life with the calling into being of the Native Affairs Commission, and with it the hope, so often deferred during the last twenty-five years, of progressing with native industries, shines bright again.

The Prime Minister, who is also Minister of Native Affairs, has frankly admitted that a new stage has been reached in the development of the native races, which demands new methods. The members of the Native Affairs Commission are, I believe, thoroughly convinced that along some such lines as those sketched in this paper new opportunities must be offered to the Bantu people of the Union. Further, the members of this Association, with their powerful and far-reaching influence, can, if they will, help native industrial development out of the mire in which it has so long stuck fast, and speed it on a successful journey.

THE PRESERVATION OF OUR NATIONAL MONUMENTS.

By C. Graham Botha,
Keeper of the Archives, Cape Town.

Read July 13, 1921.

Among the several heritages which nations enjoy must be reckoned their national monuments, their relics of bygone days. Many nations possess a variety of reminiscences of long ago. Some are only of passing interest, others have a scientific and historical value which cannot be under-estimated. These tell us something not only of the people who created them but also aid us in linking up facts not to be obtained elsewhere.

Very often a building, a stone, or a piece of paper will unravel more mysteries than we can ever imagine. A stone or broken implement picked up can give us a clue which will settle a controverted point or add to our present knowledge. We cannot and should not ignore the smallest evidence which will help us in our studies.

Need anyone ask what is the use of all these traces of the long ago? The archaeologist knows their value and the scientist is ever watchful for the latest discoveries. They tell us something of the people who lived in the centuries gone by, they aid us to recreate the past and inform us of the manners and customs of those who have gone before. Are not many of us trying to learn something of the ages past, are we not delving into records of the country to obtain a true history of it? Where these are deficient do we not seek for the remains of what our forebears have left of their work? Take the early history of Egypt, Greece, and Rome. Are we not indebted to those who have discovered and are still bringing to light the remains of cities, villages, buildings and stones of hundreds and even thousands of years old? From these evidences we know much about the early people of those countries. We are able to recreate their story, to learn of their manners and customs, arts and sciences, and the extent of their civilisation.

If we acknowledge these facts then why should these monuments not be preserved and why should those which are in the making and will stand as links of the present to the future generations not receive the same attention? I feel confident that no one will deny this duty. It is a duty which should be recognised by every nation. In Europe most countries have laws by which their ancient landmarks are preserved and rescued from the hand of the vandal.

South Africa can claim a history of little more than two and a half centuries as far as European civilisation is concerned. Scattered over its area of the Union are monuments and relics which tell us of the early struggles of the pioneers, their defeats and successes. Here and there are marks of their progress which show the development and opening up of the country. Too few

of these witnesses remain, and it is our bounden duty to protect them and hand them down to the future generations. In Capetown, the mother city, is the Castle which reminds us of two and a half centuries that have passed by. It is our oldest monument of the days since the first Dutch settlement. Within its walls the affairs of state were settled for a century and a half, and round it was woven the military, civil and social life of the Cape. It was the pivot round which the early civilisation centred.

I will not dwell on the various buildings in Capetown which record the life of the 18th Century, but would like to mention the Old Town House which now holds the collection of Dutch and Flemish Masters, the Koopmans de Wet Museum, which exemplifies a gentleman's residence of the 18th Century, two of the oldest church buildings with their carved pulpits by Anreith. All these can be looked upon as monuments of a national character.

Here and there are stones which record the days of the Dutch East India Company, and which should receive our attention. Such are Van Plettenberg's stone erected at the bay bearing his name in 1778, and the boundary stone put up by Governor v. d. Graaff and now in the town of George. There still exists one of the Company's beacons put up to mark its boundary. We all know the fate of the Van Plettenberg's Beacon erected near to what is now the town of Colesberg. For generations this marked the furthermost boundary of the Colony. A small portion is now in the South African Museum, but the original stone had suffered from time to time from the hand of the vandal. And so we could go through a number of landmarks of this kind.

But we have another kind which is found in various areas. There are many fortifications which tell us of the 18th and 19th Centuries. The old line of defences around Capetown, the military forts in the Eastern Province, the old Fort at Durban. All these require our attention. There are also some of the Drostdy Buildings in the Cape Province, as at Tulbagh and Uitenhage. These played quite an important rôle in the early days.

What must we do to preserve these relics of another age? It is necessary to awaken the people of the country to their national responsibility. The people of South Africa have now developed a strong national consciousness, and this spirit should be fostered in every branch of their national life. Until they are fully alive to the fact that the preservation of our national monuments is a duty which falls upon everyone, we shall fall very short of what should be done. There still remains much for us to do, and by stimulating this desire to preserve the records of the past we shall be furthering this worthy object. We must not forget that in this work we should inculcate a spirit of reverence in the children, who will become the citizens of the future, and would have then learned the value of and necessity for preserving our national monuments.

IRVING FISHER'S PROPOSALS FOR STABILISING THE VALUE OF MONEY.

By Mabel Palmer, M.A.,
Durban Technical College.

Read July 13, 1921.

Abstract.

The subject matter of this paper may be summarised as follows: —

The Evils of a Fluctuating Standard.

(a) Those due to *rising prices.*
Debtors gain at the expense of creditors and hence there is discouragement of saving. Primary producers, merchants and manufacturers gain; hence accusations of profiteering occur. Wage-earners and the salaried classes lose; hence discontent and labour troubles arise. All those working under contract or relatively fixed payments lose, for example, railway and tramway administrations and local authorities, hence there is a slackening in the rate of public improvements.

(b) Those due to *falling prices.*
Creditors gain at the expense of debtors, as shown in the case of war debts.
Profits fall and enterprise is discouraged, hence bad trade and unemployment ensue. Farmers and other primary producers lose, while wage-earners gain.

(c) Attempts to fix a *minimum wage* under a fluctuating currency are futile.

(d) If a paper standard replaces gold, the rate of inflation in different countries varies, and the *violent fluctuations of the foreign exchanges* add another uncertainty to the trader's difficulties.

Causes of the Fluctuations.

Recent violent variations in price have been due to the substitution of paper money for gold, and prices have varied to an astonishing extent in proportion to the volume of paper money issued. Hence many eminent economists advocate a speedy return to the gold standard. This will mean a rapid fall of prices, with all the disadvantages noted previously.

Disadvantages of the Crude Gold Standard.

Gold is not a perfect standard. Its rate of production and therefore (to a much smaller extent) the amount in circulation

varies and prices vary therewith. In England prices fell roughly 40 per cent. between 1873 and 1895, and rose 35 per cent. between 1890 and 1914.

Need of a Stable Standard of Value.

The one great need of our currency system at present is a standard of value, a money unit which shall always, on an average, exchange for the same amount of goods, or, in other words, which will keep the price index number constant or approximately constant. Other units of measurement have been stabilised. Can we stabilise the unit of value? Stabilisation will be attained when the amount of money in circulation increases and decreases in proportion to the volume of goods seeking exchange. There is no reason to believe that the chance fluctuations of gold mining stand in any necessary relation to the volume of trade. Therefore, a mere return to the crude gold standard, while it is preferable to a paper currency with its erratic movements, will not provide an ideal or even a satisfactory standard of value. It is preposterous to state financial contracts in a fluctuating standard.

Irving Fisher's Proposal.

Professor Fisher proposes the establishment, or in the United States the continuation, of the gold standard, and the free deposit and withdrawal of gold from the Treasury. But in place of making the pound or the dollar equivalent always to a stated *weight* of gold which necessarily varies in *value*, he proposes to vary the weight in order to make it equivalent always to the same value. This is to be achieved

(a) By withdrawing gold coins from circulation and concentrating all the gold used for currency in the hands of the Government or its agent (Mint, Treasury, Central Bank, as the case might be).

(b) By issuing gold certificates corresponding to the amount of gold so held and by the free exchange by the Treasury of gold for certificates and of certificates for gold on demand.

(c) By varying at intervals of not less than two months the amount of gold to be exchanged for a gold certificate in accordance with the rise or fall of prices as shown by the national index number. It is suggested that as prices rise one per cent. the amount of gold to be exchanged for a gold certificate should also be increased by one per cent., thus the amount of currency would be decreased and prices would tend to fall. On the contrary, if prices fell one per cent., the amount of gold exchanged for a gold certificate would be decreased by one per cent., the number of gold certificates would be increased and prices would tend to rise.

Technical Details.

(a) It is admitted that the system would break down unless accompanied by sound banking, that is, a system in which the

issue of notes and the granting of bank credits are restricted by the obligation to give gold certificates on demand. But the proposed stabilisation would mitigate the effects even of unwise banking.

(b) It is proposed in order to *prevent speculation* in gold to charge a brassage fee, say of one per cent., on the deposit of gold, and to provide that no single alteration in the value of the gold to be redeemed by the gold certificate shall exceed this fee. This would prevent short period speculation; and speculation over a longer period would be prevented by the loss of interest involved in holding the gold.

Possible Objections.

(a) Why has it not been tried before? Because it depends essentially on public confidence in the accurate calculation of *index numbers*, and that has only recently been achieved.

(b) What about *foreign exchanges*? (i) The importance of this point is exaggerated. Internal trade is much greater in volume than external, and a country with stabilised money would reap so many internal advantages that it could afford to disregard the less important external inconveniences. (ii) But the inconveniences too are exaggerated. A change in the exchange between two countries corresponds in the long run to the divergence in their price levels. Suppose that the free import and export of gold has been re-established and that there has been a new vast discovery of gold on the Rand, with the result that prices rise 50 per cent. Suppose further that South Africa stabilises her currency, and that England allows her prices to rise. The South African sovereign increases in weight from 113 grains of pure gold to 169½ grains, but prices as expressed in pounds, shillings and pence remain at the old level, while English prices increase to half as much again. The South African exporter would get 50 per cent. higher prices for goods sent to England, but on his draft for the amount received he would lose 33 1-3rd per cent. on the exchange, and would on balance neither gain nor lose. Conversely, an importer would pay higher prices, but need only put down £66 13s. 4d. to purchase £100 in England. Doubtless the situation would not be so simple nor so extreme as this imaginary case, but if the movement of gold were free, exchange would always tend to fluctuate round the gold par, which would itself change as the supply of gold varied, so as to keep prices stable in South Africa. Further, this alteration in the par of exchange would prevent any undue drainage of gold from any country.

The country which first re-establishes free movement in gold stands to gain enormously, and, if, at the same time, it institutes a stable price level, it will have a long start over other nations in commercial development.

Establishment of the New System.

It is not probable that South Africa, a country relatively so backward in industrial organisation and so entangled in the

currency difficulties of the United Kingdom, will inaugurate the new system. Yet it may be noted that it already possesses all the pre-requisites of the system save the free movement of gold, that is, the central gold reserve, the gold certificates, and the regular monthly publication of official index numbers. Further, the early re-establishment of a gold standard is more essential to South Africa as the premier gold-producing country of the world than to any other. Re-establishment must either be delayed or be accompanied by widespread trade convulsions, if the old level of prices is to be restored. Therefore South Africans in particular should give very careful consideration to the Yale professor's proposal for the institution not of a crude but of a stabilised gold standard.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

(1921, DURBAN.)

Vol. XVIII. JUNE, 1922. Nos. 3 and 4.

ASPHALT IN RELATION TO ROAD CONSTRUCTION.

BY

D. Basil W. Alexander,

Borough Engineer's Office, Durban.

Read July 13, 1921.

In this paper the writer proposes to treat the subject of Asphalt Construction under two main heads, viz., Asphalt and Construction. First, then, Asphalt will be considered. This will be sub-divided into Natural and Artificial. The former will be further divided into Rock Asphalt and Lake Asphalt, and the latter will treat of Oil Asphalt.

As a general introduction to this subject it will be germane to define asphalt in order to give a clearer understanding of terms concerning which there is a good deal of confusion. It may be defined as a more or less plastic solid formed by the mixture of mineral matter in varying proportions with a naturally occurring bitumen. The term "naturally occurring" is introduced in order to distinguish them from the bitumens derived from coal and shales. Some critics may contend that it will exclude oil asphalts, which are merely an accelerated form derived from the basis of all true asphalts, viz., asphaltic petroleum.

Clifford Richardson says:—

> "Asphalt may be defined as a mineral plastic, found in nature in a more or less solid state, or recovered as such from an asphaltic petroleum in which it occurs in solution, consisting of a homogeneous mixture of hydrocarbons of the asphaltic type with a small proportion of their sulphur and nitrogen derivatives, melting on the application of heat, and miscible in all proportions with heavy asphaltic oils, or flux, to form a viscous cementing material which is used in the construction of pavements and roads, and for other industrial purposes."

This definition, while very comprehensive, takes no cognizance of the asphalt formed in the still at high temperatures by polymerization or the molecular condensation of lighter forms to a solid form. That this does occur has been often noted by the writer during

the re-distillation of heavy distillates from an asphaltic petroleum, when the residue remains as a solid asphalt-like substance. So it would seem that oil asphalt does not occur solely in solution in the same way that paraffin wax may be dissolved in petrol and recovered by heat in original amount, but is partly formed at least, as stated above, by polymerization induced at elevated temperatures. Be that as it may, we cannot refuse to recognise a residual pitch from an asphaltic petroleum as an asphalt merely on account of its partly pyrogenetic and accelerated origin.

To the oft-quoted "man in the street" it may be a matter of surprise that there should be any difference between the various kinds of asphalt, but there is as much difference as there is in different kinds of wood. If you desired a piece of furniture that would last for a long time you would choose a slow-growing wood like mahogany or oak, rather than a quickly growing one like willow; and a little reflection will show that asphalt is no exception to the general rule that the quality of a product in regard to a special purpose is the effect of the treatment resulting in the perfection attained, and proved by usage. As an example, iron ore is found combined with oxygen as haematite, magnetite, limonite, etc., or with sulphur as iron pyrites. Smelting these ores gives wrought iron; and as such by further treatment it is converted into cast iron and steel. Further addition of other elements to the steel gives a material that is particularly adapted to various usages, such as high-speed cutting tools, automobile parts for toughness, artillery, etc. So it is seen that the treatment of the crude material gives the perfected product for particular purposes. Naturally you would not expect to treat a hydrocarbon, such as petroleum, by a method as severe as the high temperature of smelting iron; its very nature presupposes as low a temperature as possible being used to complete the reduction to a solid form. The lower the temperature the longer the length of time in production and the higher the quality attained.

Native Bitumens according to Clifford Richardson consist of a mixture of native hydrocarbons and their derivatives, which may be gaseous, liquid, a viscous liquid or solid; but if a solid, melting more or less readily upon the application of heat, and soluble in turpentine, chloroform, carbon bi-sulphide, similar solvents, and in the malthas or heavy asphaltic oils. He further says coal is not a bitumen because it is not soluble to any extent in the usual solvents for bitumen, nor does it melt at comparatively low temperatures, nor dissolve in heavy asphaltic oils. But on distillation it gives rise to products that are similar to natural bitumens, and are therefore termed pyro-bitumens. We may therefore look upon bitumen as that portion of asphalt, wherever found, soluble in carbon bi-sulphide, and asphalt as the mixture of a certain type of petroleum bitumen with varying amounts of mineral matter. The latter may be as high as 90 per cent. or more, as in a sheet asphalt pavement; or as low as 0·1 per cent., as in the residual pitches derived from the asphaltic petroleums. It is in this sense that the term is used in this paper, further

stating that by the term "pavement" is meant the wearing surface of a street or road, when it has been "hardened."

With this preamble, the essential topics of the paper may now be considered.

Rock Asphalt, or Bituminous Sand or Limestones.

This material is noteworthy as being the father of the modern asphalt pavement, and in past years has been much more extensively used than it is at present. The reason is not far to seek. Recent investigations have shown that an asphalt pavement depends largely for its life on the grading of the mineral matter, perhaps as much so as on the quality of the bitumen, though the latter, being a component of about only 10 per cent., is a determining factor of long life. However, Nature has no recognition of standard gradings, and she permeates any available pervious stratum with the soft asphalt under pressure; consequently they vary very considerably in their grading in different deposits, and sometimes even in the same one. However, it must be granted that, whatever the grading, the bitumen must be in the correct amount to fill the voids. This probably governs their success. A fine sand stratum would take up and retain just enough to cover each individual grain with a thin film of bitumen as the stream was forced through and proceeded onward. The amount would be more than in a coarse stratum because of the greater surface area, but because of larger voids the latter would have greater masses, and therefore more be easily displaced when laid as a pavement. For this reason the finer rock asphalts give greater satisfaction than the coarser where the traffic is at all heavy. This non-uniformity of grading is responsible for many of the failures of rock asphalt, so attempts have been made to make it more uniform by breaking up and grinding, especially with the European varieties, and some more successful pavements and sidewalks have been laid in that condition.

Another reason for the decline in the use of rock asphalts, besides the chance grading, is the expense entailed in shipping and paying for freight on a lot of unnecessary and often inadequate mineral matter which (since sand is available anywhere) can just as well, and in fact better, be introduced where the pavement is to be laid. Another disadvantage is that there is no method of knowing or controlling the penetration of the cementing bitumen, a frequent source of failure. It is generally conceded that rock asphalt pavements are more slippery in wet weather than any other form of pavement except perhaps wood.

Lake Asphalt may next be considered.

Lake Asphalts.

Lake Asphalts may be classed under two varieties, Trinidad as coming from the Island of Trinidad, British West Indies, and Bermudez as coming from the mainland of Venezuela. They both occur as vast deposits which take the form of lakes—hence the name.

Trinidad Asphalts.—This deposit, known on the Island of Trinidad as the Pitch Lake, is owned by the British Government, and is mined by companies who pay a royalty to the Island Government on every ton of crude asphalt removed from the deposit. This royalty amounts annually to more than one-quarter million dollars (£52,000).

The Pitch Lake is 114 acres in area, and over 150 feet deep near the centre. The actual depth has never been ascertained because the deposit is in constant motion, so the boring drill is eventually broken off, or the hole becomes crooked so that the operation stops. More than 170 million square yards of city pavements have been laid with this asphalt since 1870 in the United States alone, not to mention many miles in other parts of the world.

The asphalt in this deposit contains about 29 per cent. of its weight of water, the removal of which constitutes the refining process. This is done at about 325° F. by means of steam coils, closed coils to heat it, and open coils to agitate. Asphalt is a poor conductor of heat, so that it is necessary to get all of the asphalt in a molten condition to facilitate the evaporation of the water. For the same reason it is best to get the heat disseminated throughout the mass as quickly as possible. A kettle or still heated by direct fire would be a dangerous procedure as it could not be agitated in the early process of heating, and the material would tend to cake on the bottom. The kettles (called steam stills) are square tanks capable of holding 70 tons, the lower half being funnel shaped. The lower portion is filled with the closed steam coils conveying steam at about 125lbs. pressure, giving a temperature of about 325° F., which naturally is never exceeded. Trinidad asphalt melts at about 180° F., so that this temperature is sufficient to bring the material to a state of fluidity, and when in this state steam at the same temperature and pressure is admitted through the open coils, which are perforated pipes placed at the bottom of the still under each individual heating coil. The effect is to raise the temperature of the portions lying away from the vicinity of the heating coils, and violently agitate the mass, thus assisting in the removal of the water from the crude asphalt. This operation takes about 8 hours. When the water is all removed, the live steam is shut off and the mass becomes quiescent; then the sticks and other refuse rise to the surface and are skimmed off. The heating steam is kept on until the operation is complete, when the hot material is run off into barrels, which, when cool, are ready for shipment.

When refined, the asphalt contains 56 per cent. of bitumen, the remainder being a very fine clay. It is the presence of this clay in a colloidal state that gives the stability of mixtures made with Trinidad asphalt. The difference in stability exhibited by the method of incorporating a colloidal clay in a liquid asphalt can be demonstrated. In the one case it is incorporated by a method similar to the manner in which it is introduced in Trinidad asphalt, and in the other the way it is mixed in the paving plant. To illustrate: a sample that still retains the spiral form can be

made by mixing clay into a slurry with water and adding it in that state to the hot liquid asphalt; then heating to 250° F., and stirring until the water is all expelled. It is then cooled and made into a spiral, and put into the test-tube. In the sample that is deformed and shows no stability the dry clay is mixed into the hot liquid asphalt at 250° F., and stirred at that temperature for the same length of time as the other; then it is cooled and made into a spiral and put in a test-tube just as the other sample was.

Exactly the same proportions of the same ingredients are used in each case, and as the tubes are always being kept side by side they are at all times under similar physical conditions; yet the "wet" mix (Nature's method at Trinidad) shows its original spiral form, while the "dry" mix (man's method at the plant) has completely deformed, and shows only indications of its original spiral form. The presence of this colloidal clay in Trinidad asphalt may be demonstrated by immersing a piece in distilled water for about two weeks. At the end of this time it will be noticed that the asphalt is covered with a brown powder, which may be washed away, exposing the unaffected bitumen underneath. The explanation of the phenomenon is as follows:—Each particle of the colloidal clay in a perfectly dry state is enclosed in a thin film of bitumen. The water, by osmosis, passes through this film and moistens the anhydrous clay, which therefore expands and bursts the enclosing film, allowing the hydrated clay to escape. If this is washed away, the film of bitumen remains adhering to the unaltered underlying material; or if the surface is heated the bitumen is melted, the water evaporated, and it resumes its former condition. The question might arise, if water has this effect upon Trinidad refined asphalt why does it resist for so long the combined action of atmospheric and traffic influences? The question is answered by the above explanation, which gives the conditions in an exaggerated form, for no street remains under water for a couple of weeks. In the course of time the liberated clay is removed by the street cleaning gang while the bitumen remains in the form of a thicker film. This decreases the action of osmosis, so the surface is ultimately sealed and the water action stopped without affecting the stabilizing action of the colloidal clay.

The origin of the Pitch Lake is not very evident, but taking it in connection with what is known of the surrounding country and of other localities, an explanation, at least plausible, can be afforded. An inspection of the map shows the country has been, and still is, volcanic, as evidenced by the eruption in Martinique in 1906, the more recent one of San Salvador in 1917, and the still more recent one of Irazu in Costa Rica in 1919. Where volcanic agencies are sleeping but not dead, the springs are frequently warm, even boiling, and if superheated become solfataras. These outlets may be many miles from the source of their heat deep down in the earth, and therefore under great pressure. In passing to that outlet these streams may encounter a stratum of clay, or other fine mineral matter, through which they tear their way, take up the earthy matter, and become the mud-springs, such

as are known to occur in many parts of the world. Again the mineral matter in its colloidal state may be produced in another way: Warm alkaline water dissolves silica; if it is made acid it loses its solvent power, so the silica is precipitated in so finely divided a state that it is gelatinous. The quantitative analysis of silica is based on this same principle. Now the water in the soft pitch as it rises near the centre of the Pitch Lake is alkaline (Clifford Richardson, Pop. Sci. Monthly, July-Aug., 1912), but in the crude asphalt it is acid (C.R. ibid), giving just the conditions requisite to produce colloidal silica.

Within recent years a high grade asphaltic petroleum has been found about 2,000 feet deep in the vicinity of the Pitch Lake, which is doubtless the source of the lake. Let us apply then the foregoing to the formation of Trinidad asphalt in the theory as outlined by Clifford Richardson. The depression in which the Pitch Lake occurs was probably in olden times just such a mud spring as is described above, erupting under great pressure. Then the petroleum under its own gas pressure broke through into the friable stratum of clay, finally reaching the vent through which the hot mud spring was forcing its way. There it was mixed and thoroughly churned on its way to the surface, so that it became an intimate emulsion of oil, mud and alkaline mineral water, the various component parts being admitted to the mixture in definite amounts according to the various sources of supply and their pressure. The presence of water in the mud tends to prevent any excessive heat, and it is probably not in the vapour phase because of the great pressure which brings the material to the surface against the weight of a plastic mass of asphalt over 150 feet deep, which it keeps in constant motion.

The conditions as postulated above are similar to those in an oil refinery, producing what is known as B.S. (Bottom Sludge), an emulsion of oil and water formed by the churning action of steam on hot oil in the condensers, and there cooled. It is well known and severely anathematized by every oil man; similarly Trinidad asphalt.

The petroleum mentioned above as being the source of Trinidad asphalt is unique in its structure inasmuch as the removal by heat of a small fraction at a low temperature leaves a residue which is a liquid asphalt, there being no intermediate fractions (kerosene, neutral and gas oils) between the light naphtha and the lubricating oils, so that a low temperature only is necessary to reduce the crude petroleum to a liquid asphalt. Thus it happens that the crude oil emulsion readily loses its lighter portions by a species of film distillation from the hot colloidal particles, whereby a small amount of heat is enabled to do a large amount of volatilization in reducing an oil to a hard asphalt.

Though it begins to melt about 180° F. it does not become properly liquid till about 300° F. It has a consistency of 4° by the penetrometer, and since this is harder than it would ever be used in that condition it is softened by the addition of an asphaltic flux to any degree of softness desired to suit conditions of traffic,

climate and grade for any job in any city. It will stand a higher temperature without deterioration than other asphalts with more bitumen.

BERMUDEZ ASPHALT.—Although probably derived from the same oil horizon as the Trinidad Pitch Lake this deposit differs in its physical but not chemical characteristics. It is softer and more ductile, and contains about 95 per cent. bitumen. The deposit is about 140 miles due west in an air line from the Trinidad deposit, is about 1,000 acres in extent, but much shallower, being 9 feet at the deepest part. It gives no evidence of being in constant motion as the Trinidad deposit does, but is probably fed by several springs of maltha over a large expense of territory. On account of its softer consistency a smaller amount of flux is needed to bring the asphalt cement to the same penetration as one made with Trinidad asphalt. Also because of its greater bitumen content, a less amount is required in making a bituminous mixture, but a larger amount of dust for filler must be added by the less effective dry method, and then it is not as complete as the Trinidad colloidal material. On the other hand its freedom from colloidal clay gives it a lower melting point (about 180° F.) and a penetration of about 20°. It also makes a better material for producing a bituminous macadam by pouring the hot material on crushed stone in the construction of country roads and highways. Its physical similarity to Trinidad bitumen is shown by its tenacity in adhering to stone, and staying where it is put for a number of years, which is due to the quality of the bitumen, for it, like Trinidad, has taken hundreds of years to arrive at the solid consistency necessary for a basis to work from. It is similarly refined and fluxed.

Various characteristics show that the bitumen of these two lake asphalts is very similar, and that they are probably derived from the same petroleum. One of the most notable characteristics is the comparatively large amount of sulphur (6 per cent.) that exists in a firmly combined state, whereby the otherwise unsaturated hydrocarbons are made saturated compounds, assisted probably by a polymerization and condensation of the molecules, and are therefore in a condition of stable equilibrium. This tends to keep them "alive" when laid as a pavement, and satisfactorily accounts for the long life of the structure with a minimum of repairs.

OIL ASPHALT.

Oil occurs in different forms and composition in various parts of the world, and probably more generally than is usually suspected. It occurs in two forms, natural and artificial, and by the latter term is meant of pyrogenetic origin, such as the oils obtained by the destructive distillation of wood, coal, fats and certain shales. It will be therefore readily surmised that oils occur of very different chemical composition. The natural oils may be subdivided according to whether they occur *on* or *in* the earth. The former include the animal and vegetable oils, and the latter the petroleums, or mineral oils, ignoring their probable or improbable ultimate origin. It is with these latter that I propose to deal in

this paper, and for this purpose these petroleums may be subdivided into asphaltic, semi-asphaltic, and non-asphaltic. The latter are the products from the oil fields of Russia, the Eastern and other isolated fields of the United States of America, Borneo, etc.

The asphaltic and semi-asphaltic petroleums only are used for making the oil asphalts. The latter are found in the eastern fields of Mexico, some of the American States, as Texas, Kansas, Oklahoma, while the true asphaltic petroleums are found in the Island of Trinidad, British West Indies, the Western American States of California, Wyoming, and others.

All these differing petroleums are found singly in fields, or even doubly, as no field, territory or state has a monopoly of one variety. As a matter of fact any oil well in any field may differ in point of gravity from the well next adjoining it. This may, and probably will, result in non-uniformity of the asphalt produced in any refinery, and especially if it is supplied with petroleum from different fields.

From wherever obtained the petroleum is received at the refinery into a storage tank holding perhaps 55,000 barrels. This is usually provided with steam coils in order to heat the oil and to facilitate the settling out of the water that is nearly always present. From here it is pumped into a cylindrical iron still holding from 125 to 350 barrels fitted with perforated steam pipes along the bottom, and a fire is kindled under the still. Now petroleum is a mixture of various complex hydrocarbons having different boiling points. The effect of the heat is to drive off those hydrocarbons having the lowest boiling points which pass as vapour from the still to the condenser, where they resume the liquid phase; thus the temperature gradually rises. At about 300° F. steam is admitted through the perforated pipes to agitate the oil, and assist in the removal of the distillates. As the temperature rises the distillates evolved get heavier, and the residue in the still becomes more concentrated until a temperature of about 700° F. is reached. At this temperature the material in the still is thinly liquid, and the vapours, assisted by the steam, come off as a heavy yellow gas, which, when cold, yields lubricating oils. It is accompanied by a copious evolution of sulphuretted hydrogen, indicating the decomposition of the sulphur compounds. On account of the increasing weight of the distillates the steam has been gradually increased until three or four times as much is used as at first. By increasing the agitation this tends to prevent excessive decomposition of the oil against the hot bottom of the still heated by the fierce flame of the fire, which has also been gradually increased. The increased steam is not entirely successful, and a certain amount of coke collects on the bottom of the still, and the fire-line carries a black scum of decomposition products. This stage of the process requires great skill to keep the temperature ahead of the boiling point as a drop in temperature of only a few degrees would result in the condensation of the vapours inside the still which would drop back into the hot oil; increased decomposition ensues

(technically called "cracking"), and the material is deteriorated. This gives a condition in the product known as "Carbonos," and estimated as being the portion soluble in carbon bi-sulphide but insoluble in carbon tetra-chloride.

The temperature is maintained at about 700° F. until sufficient of the hydrocarbons constituting the lubricating stock are removed to give a residual pitch of the desired consistency. It was formerly the practice to run down to a low consistency in order to get out the valuable heavy lubricants, and flux back to the desired consistency, imitating the method in vogue with the lake asphalts, but it is now conceded that a better material is obtained if the distillation is stopped when the required consistency is reached. This is determined by the still-man by drawing a sample from the still, cooling it in water, and chewing it. This is a crude method, but it has the advantage that the apparatus is always available, and the temperature of the test always the same A "chewing sample" of known consistency is supplied by the laboratory for practice, and some still-men get very expert in grading a batch by this method, others pretend to be. When his judgment decides by this test that the correct grade has been reached the fire is extinguished, and the still is drawn into the cooling kettle, from which it is barrelled while still warm enough to flow readily. Some still-men draw the fire before the grade is reached, and come to grade by steam alone. A sample is taken during the barrelling process to be tested in the laboratory by the penetrometer, and the figure obtained is called its "penetration." If it is not of the correct penetration it can be modified, when used, by mixing with another batch either harder or softer as the case may be.

Asphalt made in this manner is practically 100 per cent. bitumen. The term has no technical value, as the petroleum from which it was made was that also. The operation of distillation is completed in from 24 to 36 hours. On account of this rapidity of manufacture the hydrocarbons are in a state of unstable equilibrium, and during subsequent years are constantly endeavouring to reach a position of rest. This results in a gradual hardening of the asphalt, and a consequent brittleness that conduces to disintegration of the pavement. The same action is noticed with coal tar and its derivatives by heating, but in this case there appears to be reason for its success—and its failure.

Having thus briefly described the sources of asphalt as used in the paving industry, we will pass on to the subject of combining it with the mineral aggregate to construct the modern sheet asphalt pavement. This may be considered under two heads: Ingredients and Combination.

Ingredients.

The bitumen in a sheet asphalt pavement amounts to about 10 per cent., the remaining 90 per cent. being a well-graded mineral aggregate consisting of sand and a fine dust. This aggregate grades from a 10 mesh sieve, having 100 openings to the square

inch down to the impalpable dust passing a 200 mesh sieve, having 40,000 openings to the square inch. The sand is selected to take the gradings from the 10-mesh sieve down to that retained on the 200-mesh sieve. The dust carries the grading further from that passing the 200-mesh down to the impalpable dust that will not settle in water during 15 seconds. This decreases the size of the voids to that of the finest material, and the bitumen completes the process by covering each particle and cementing them together. The point of most importance is the one most frequently overlooked, namely, the character of the fine sand. This has a double purpose. First, it increases the surface area and surface energy, and second, it lessens the voids, and distributes the particles of dust throughout the mixture, thereby increasing its stability by making it denser, and also more waterproof.

The best sand grading has been found by the examination of successful pavements to conform to the following mnemonic figures:—

Traffic.	Heavy.	Light.
Passing 80 mesh sieve	33 per cent.	22 per cent.
Passing 40 mesh sieve	44 per cent.	44 per cent.
Passing 10 mesh sieve	22 per cent.	33 per cent.

It is very seldom that a single sand is found that fulfils the conditions of the above grading, so two or more sands are combined in order that the mixture will approximate as closely as possible to the standard. Durban is fortunate in its supply of coarse and fine sand situated as it is between the Umgeni River on the east, and the Umbilo on the west. The former, being a long and swift river, supplies the coarse sand; while the latter, being comparatively short and sluggish, supplies the fine, or tempering, sand. These effects are due to the well-known transporting power of moving waters. As an example of the grading of the sands from the respective rivers we have:—

	Umgeni.	Umbilo.	Mixed 1 to 4.
Passing 200 mesh sieve ..	—	9	7
Passing 80 mesh sieve ..	2	38	31
Passing 40 mesh sieve ...	9	52	43
Passing 10 mesh sieve ...	89	1	19

These two sands are supplied to the cold material elevator in the proportion of one barrowful of the Umgeni sand to four of the Umbilo, which gives a grading as shown in the third column. The 200 mesh sand is not desirable in a pavement, as it makes a mushy mixture, the grains acting rather as ball-bearings than wedges; however, it is mostly taken out by the draught fan of the plant.

The voids in the mixed sands are no smaller than those of the finest portions, so as these are not fine enough to give a proper stability, a stone dust, or Portland cement, is added, of which at least 75 per cent. should pass the 200 mesh sieve. Sufficient is added to give about 12 per cent. of the 200 mesh material in the finished mixture, assuming it is to sustain a heavy traffic. Having reduced the voids to the size of those in the finest of the dust, the whole, while heated to about 350° F. is mixed with hot

asphalt cement in sufficient amount to give each particle, large and small, a thin coating. When the asphalt cement in use is made from Trinidad asphalt the voids are still further reduced by the presence of the colloidal clay mentioned in the earlier part of this paper. The reason for the difference between the sand gradings for heavy and light traffic is to allow a greater play for contraction and expansion by reason of the larger voids, and therefore thicker film of asphalt cement. That this is desirable is readily understood, because if a pavement cools while quiescent, the contraction will continue until it reaches the limit of the ductility of the asphalt cement, and the pavement will crack at the weakest point. If, however, this increasing tension is relieved by the shock of passing traffic, adjustment ensues and rupture is prevented, and the contraction commences again at the zero point. Where traffic is infrequent this shock is not imparted, and the pavement cracks. However, if the film of asphalt is thicker, as in a light traffic mixture, the greater mass of bitumen will stretch farther and accommodate itself to the new condition, so that the pavement will remain intact. This has been frequently observed by the writer where an isolated piece of pavement has cracked while the rest of the pavement, made and laid at the same time with the same mixture, but subjected to traffic, has remained in good condition. Thus it may be seen that traffic is the life of a pavement. This is also true for the reason that traffic will give a greater compression than that obtained by the use of a roller when the pavement is laid and is still hot. It will be readily seen that the weight of a trolley loaded with one ton on two inch tyres will have a greater compressing effect than a five-ton roller supported on two four-foot wheels, and distributed over that distance, even if the pavement is hot in the latter case and cold in the former. This is generally the reason for the marking that all new pavements should show when first opened to traffic. As traffic continues these marks iron out until the mixture has received its ultimate compression. A light traffic mixture will naturally mark more readily than the closer and more compact heavy traffic mixture.

Dust or Filler.—Of this ingredient little need be said in this paper except that it should be very fine. As stated before at least 75 per cent. should pass the 200 mesh sieve, and of this portion certainly 50 per cent. should remain suspended in water at 68° F. when agitated and allowed to settle for 15 seconds, as determined by the elutriation test. The dust is added cold in predetermined amount to the hot sand, and mixed thoroughly with it in the mixer before adding the asphalt cement, and it is here that the value of the fine sand is felt in breaking up the masses of dust and disseminating it throughout the sand; otherwise the masses will be coated with the asphalt cement and cause weak spots in the pavement, and the mixture will be lumpy.

Asphalt Cement.—A.C. is the technical designation for asphalt cement, and has been mentioned sufficiently under "asphalt." It is modified in penetration (consistency) to suit any

condition of climate, traffic and grade; and in amount to suit degree of traffic it will be called upon to sustain, and the mineral aggregate available or required for the type of pavement to be laid.

Combination.

The cold sand is deposited in the predetermined proportions at the foot of the cold-material elevator of the paving plant by which it is conveyed through a chute into the sand drier, a revolving drum heated underneath by a coal or oil fire. This drum is inclined at a slight angle towards the back end of the plant. It is provided with staggered flights of angle irons rivetted longitudinally on the interior of the drum. This arrangement lifts the sand as the drum revolves until the inclination is so great that the sand slides off, and falling through the hot gases now returning through the drum is deposited a little in advance of its starting point; and so it eventually reaches the end where it falls through a chute into a boot at the foot of the hot sand elevator. From here it is lifted vertically by the bucket elevator and dumped through another chute into a revolving screen, half of which is made of $\frac{1}{8}$ inch wire mesh, and the other half of a 1 inch wire mesh. Here it is screened into sand and rock respectively passing and retained on the $\frac{1}{8}$ inch screen which falls into bins underneath. The rock rejected by the 1 inch mesh screen passes away from the plant, or if desired it may all be received into the rock bin. From the bottom of the bin the hot sand at about 350° F. passes through a swinging gate into the sand box supported on the platform of a triple beam scales whereby the correct weight is obtained. The dust is added cold in predetermined amount to the hot sand, and the total aggregate is passed through a gate into the mixer. Here it is given a dry mix for about 15 seconds, and then the correct weighed amount of asphalt cement at about 325° F. is added, and the whole is mixed for at least one minute, or until it is a homogeneous, bright black mass like a blackberry in appearance. By means of a slide gate in the bottom of the mixer it is dropped into a wagon. A sufficient number of batches are dropped in to complete the load, which is then hauled to the street, dumped, spread with shovels, raked to the required thickness, and rolled till too cold to take more compression. This is a brief outline of the construction of the wearing surface of a sheet asphalt pavement. In order to prevent movement on the foundation an intermediate layer, called the binder course, is interposed. This is made from the one inch rock in the other compartment of the sand bin mixed with about 25 per cent. of sand, all cemented together with asphalt cement. The increased friction of the stone holds the pavement firmly to the foundation under the shoving effect of traffic.

Asphalt Concrete is made similarly, being a sheet asphalt mixture with about 30 per cent. of $\frac{3}{4}$ inch stone added. The addition of the stone will decrease the surface area, and therefore the required amount of A.C. and dust; and is therefore proportionately cheaper. It is, however, never laid less than 2 inches thick.

A still cheaper construction is *asphalt macadam*. This is made with a foundation course of 4 inch to 1 inch stone, thoroughly rolled, upon which is spread loosely a 3 inch course of $2\frac{1}{2}$ to 1 inch stone, which is sometimes harrowed, though the benefit seems questionable. Upon this top course is poured from pots a soft asphalt cement, at about 320° F., in an amount equal to 1 gallon per inch of thickness, so as to completely cover the stones, and bind them together. For this purpose Bermudez asphalt is used instead of Trinidad, because the melting point is lower and a portable kettle is used right on the work so that the saving in fuel is a consideration; besides this the presence of the colloidal clay in the Trinidad asphalt would necessitate constant agitation to prevent a possible sedimentation at the elevated temperature. As soon as the asphalt cement has been applied the surface is covered with $\frac{3}{4}$ to $\frac{1}{2}$ inch stone screenings (chippings), which are swept over the surface and then rolled till smooth with an 8-ton tandem roller. If a smoother surface is desired another application is made after rolling, or even after having been opened to traffic for a short time. This time the application is in a much smaller amount, $\frac{1}{3}$ gallon per square yard. It is spread with brooms, or squeegees, and then covered with $\frac{1}{4}$in. stone chippings free from dust, and all retained on a 10 mesh sieve. It is then again rolled, though this may be omitted if desired, traffic being allowed to complete the surface. This makes a very good and inexpensive pavement for country roads.

Asphalt Macadam, Mixed Method.

Where a paving plant is available a superior form of the previous pavement can be made at a slightly increased cost by means of the mixing process. The stone in use is from $1\frac{1}{4}$ to $\frac{1}{2}$ inch, and is mixed with 10 to 15 per cent. of sand. The mineral aggregate must be dry, though not necessarily hot, but the asphalt cement must be heated to 320° F., and in sufficient quantity to completely cover each stone. It is then spread and rolled with an 8-ton tandem roller. When well rolled and quite smooth a seal coat is given as described for the penetration method.

Foundation.

To the last has been left what really comes first, but it is only necessary to say that this should be adequate to sustain the traffic as imparted to it through the thickness of the surface and binder. No pavement is stronger than its foundation, and as stated by Mr. Charles N. Forrest:—

> "It must always be assumed that the foundation of the pavement is sufficient to support the surface. It necessarily follows that failure of a perfect surface is due to improper foundation. It also necessarily follows that if the foundation is sufficient, or perfect, any failure of the pavement is due to certain defects in the surface. It does not appear to be good policy to endeavour to design surface mixture with a view to compensating for certain defects in the foundation."

Bearing the foregoing in mind it is well to consider the thickness of foundation necessary to sustain the traffic it will be called

upon to bear. In this connection the investigations of the Massachusetts Highway Commission on the bearing power of soils and the distribution of wheel loads will be of interest:—

> "The Commission has estimated that non-porous soils drained of ground water, at their worst will support a load of about 4lb. per inch, and having in mind these figures the thickness of broken stone has been adjusted to the traffic.
>
> "On a road built of fragments of broken stone the downward pressure takes a line at an angle of 45 degrees from the horizontal, and is distributed over an area equal to the square of twice the depth of the broken stone. If a division of a load in pounds at any one point (i.e., of contact) by the square of twice the depth of the stone in inches gives a quotient of 4 or less, then the road foundation will be safe at all seasons of the year. On sand or gravel the pressure can be safely put at 20lbs. per square inch.
>
> "Acting on this theory the thickness of the stone varies from 4 inches to 16 inches, the lesser thickness being placed over good gravel or sand, the greater over heavy clay, and varying thicknesses or other solids. In cases where the surfacing of broken stone exceeds 6 inches in thickness the excess in the base may be broken stone, stony gravel, or ledge stone, the material used for the excess depending entirely upon the cost, either being equally effective."

If now the broken stone mentioned in the above extract were cemented together by asphalt the angle of distribution would be lessened by about 25 per cent., and the area of support more than doubled, so that the thickness could be decreased by nearly one-half.

Conclusions

It is very evident that asphalts may differ considerably in the quality of the bitumen they contain. Since in a sheet asphalt pavement the bitumen only amounts to about 10 per cent., it necessarily follows that the asphalt should be well chosen in order not to endanger the permanence of the other 90 per cent. It is poor economy to save pennies on the asphalt and pay pounds on the upkeep. No asphalt pavement is more lasting than the bitumen it contains, for the dry mineral aggregate has no inherent stability.

No satisfactory laboratory test, or series of tests, will ensure a long life to a pavement; the only reliable test is that of service, but it must be borne in mind that even an asphalt with a good record can be ruined by careless workmen. A street pavement has the same relation to the mixture in the plant as a finished photograph has to the negative in the camera; there are many points to consider in each case all bearing on the final product. For instance a perfect wearing surface may be influenced by the following defects:—

(*a*) Too much bitumen; (*b*) too little bitumen; (*c*) improper type of bitumen; (*d*) too much flux; (*e*) too little flux; (*f*) character of flux; (*g*) too much coarse sand (10-40); (*h*) too little coarse sand; (*i*) too much fine sand (80-100); (*j*) too little fine sand; (*k*) improper type of sand; (*l*) too much filler (200); (*m*) too little filler; (*n*) improper type of filler; (*o*) too hot a sand; (*p*) insufficient dry or wet mixing.

Furthermore, the pavement on the street may be influenced by:—Improper raking; allowing mixture to get too cold; smooth foundation; improper type of roller, etc., assuming binder and foundation are perfect.

I am aware that this looks like a formidable array of obstacles, but you will observe that it is not really so, as most of the conditions enumerated are settled previous to the work by the engineer in charge or the chemist. The point I wish to make is that if you want something good you must pay for it; you cannot get anything good either for nothing or cheap; and eternal vigilance is necessary in making an asphalt pavement as it is the price of success.

Furthermore, I wish to emphasise the point that highway engineering has passed beyond the happy-go-lucky, hit-or-miss, rule-of-thumb methods, and become one of the arts that is of sufficient importance to endow Chairs in Universities.

PURIFICATION OF SEWAGE BY THE ACTIVATED SLUDGE PROCESS.

BY

REG. J. MORRIS, A.M.I.S.E., M.R.San.I.

Borough Engineer's Office, Kingwilliamstown.

Read July 12, 1921.

The purification of sewage has always been a knotty problem which engineers and chemists have had to grapple with. Every town naturally desires to keep itself sweet and clean and to discharge its sewage outside. The people outside naturally do not desire it in their midst for several reasons. It is not only unsightly, but has an obnoxious odour and the disposal takes up much land. The city or town overcomes some of these difficulties by purchasing a good-sized plot of land for the sewage treatment and endeavours to render the sewage as innocuous as possible by scientific treatment.

It has long been felt, however, that the last word has by no means been said in the direction of scientific sewage disposal, and municipal authorities have been waiting for a system of dealing with sewage which would entail less capital cost, which would require less land, and would make the sewage a remunerative by-product when it was disposed of.

The Activated Sludge Process claims to fulfil all these requirements and to have revolutionised the treatment of sewage disposal.

Messrs. Jones and Attwood, Ltd., of Stourbridge, England, the makers and patentees of the Activated Sludge Plants, claim the following advantages:—

(1) Ideal purification can be obtained with absence of all aerial nuisance.

(2) A sludge of great fertilising value is obtained in place of the highly offensive, objectionable and practically valueless sludges obtained from all other processes, including the latest Imhoff tank.

(3) The land required is from one-fifth to one-tenth that of any other complete process.

(4) The first cost of the plant is considerably less than that for any other complete process.

(5) Taking into account interest on capital expended, the annual running cost will be less.

(6) In hot climates it is entirely free from the fly nuisance.

It has been known for many years that if sewage be exposed to the air for a sufficient period of time, the organic contents are gradually oxidised and a deposit of humus is formed; and, also, if the process be sufficiently prolonged, the ammonium salts and nitrogenous organic matter are largely oxidised to nitrates. Numerous investigators have from time to time endeavoured to utilise aeration methods. These efforts date back as far as 1884, when the report of the Royal Commission on Metropolitan Sewage Disposal was published. Since then many experiments have been carried out in England and America, but without any great success until 1913. In that year Dr. Fowler, who was then at the Manchester University, and Dr. Ardern, Chief Chemist to the Rivers Board Committee, together with Mr. W. T. Lockett and Mr. Mumford, experimented on new lines with most successful results. Their view was that the process of aeration was entirely due to bacterial activity. A discovery was also made of a certain organism, "M7," which is not found in sewage treated by any other method. The "M7" is also found in colliery waters. The process of purification was then known as the "M7" process. When the process began to be applied practically the name was changed to "Activated Sludge" on account of the sludge, which is one mass of intensified aerobic bacteria, and which is circulated through and through the sewage continually. The whole of the purification depends on the thorough mixing of an active sludge with the sewage, and hence the name "Activated Sludge."

Some people are under the impression that the process involves the inoculation of the sewage with a given organism under pressure of air. This is not so. There is no inoculation of any organism whatsoever. In an ordinary sewage filter the sewage passes in thin films in the presence of air over surfaces coated with an active bacterial deposit. Costly surfaces are thus required, aeration is by no means perfect, and surface action is limited.

In the activated sludge tank the bacterial sludge, which is built up in the sewage by processes similar in principle to the formation of the active bacterial deposit in the filter medium, is thoroughly intermixed with the sewage by means of air in a fine state of division. Thus practically infinite surface is obtained, and is continually renewed, and consequently the conditions of bacterial oxidation approach theoretical perfection. This is the principle which differentiates the activated sludge process from all other processes of aeration which have previously been

attempted. In giving a description of a plant working with activated sludge, I will take as an example the sewage disposal works of the city of Worcester, in England, which, owing to the kindness and courtesy of the former Engineer of the city, Mr. Thomas Caink, I had the pleasure of inspecting. I was also permitted to take some photographs, which have been converted into slides. I select the city of Worcester because the first complete installation on the continuous flow type was erected there. The plant was designed and installed by Messrs. Jones and Attwood, Ltd., under special agreement with the Worcester Corporation, whereby the payment for the installation was conditional on the successful operation of the process so as to comply with certain requirements in regard to the character of the effluent obtained, and the volume of sewage treated. The installation was designed to deal with 750,000 gallons dry weather flow. The tank placed at the disposal of the firm was 80 feet long by 72 feet wide and 18 feet deep. It was divided longitudinally into nine bays eight feet wide, which was subdivided by three transverse walls, thus forming 36 compartments. In the adoption of this tank for the trial of the process, five bays were used for aeration, and the other four for settlement purposes.

The five aeration bays are arranged as follows: The first bay, though eight feet broad at the top, is only five feet broad at the bottom, due to the batter of the outside wall. The bottom of the first bay is arranged with ridge and furrows at five feet centres, the furrows each containing five air diffusers, each one foot square over all. These are, of course, placed transversely to the flow of the sewage. The lower part of each transverse wall is cut away, making an opening three feet deep right across the tank above the top of the ridge. The ratio of total diffuser area to tank area in this bay is 1 : 5, or 1 : 7, if the actual diffusion area is considered. The other four aeration bays are arranged in pairs, each pair making a circulating tank. The bottoms of these bays are formed with ridges and furrows, saw-tooth form, at ten feet pitch, with eighty diffusers in each furrow, so that the ratio of diffuser area to tank area is 1 : 10, or 1 : 14 for actual diffusion area. Advantage is taken of the transverse walls which are used as baffles, and these, together with intermediate wooden baffles, gives a baffle alongside each side of diffusers which checks the back flow, and allows the rising current of sewage to flow forward. In this way a much more rapid horizontal circulation is secured than would be obtained by the natural flow of sewage. The mixture of purified effluent and sludge leaving the aeration chamber enters the settlement tanks underneath a timber baffle eight feet below the surface. The settled sludge is removed from a series of collecting sumps through a system of pipes to the inlet sewage chamber.

The settlement tanks have been partially reconstructed since the plant was brought into operation, as will be seen later. An overhead system of air pipes is provided, and the air is admitted to the diffuser through a series of down pipes which are arranged so that one pipe serves two diffusers, each one foot square. Valves

are fitted to each distributing pipe so that the air supply may be regulated and equally distributed. The air compressor is of the Ingersoll Rand horizontal type, and is belt-driven by electric motor (d.c.) capable of developing 40 b.h.p. When running at 235 r.p.m., it has a piston displacement of 615 cubic feet per minute and actual delivery of 562 cubic feet.

The total capacity of the settlement tanks is sufficient to allow a two hours' detention when working at the above rate, the sewage taking eight hours to pass through the tank.

The Worcester sewage cannot be termed a strong sewage as the flow is equal to approximately 40 gallons per head, and although the City Engineer states that a variety of trade effluents are discharged into the sewers, there appears to be none of an inhibitory character present in the sewage. Apart from stoppages due to structural alterations to the settlement tanks, the tanks have been in continuous operation since May, 1916.

During this period the rate of flow has varied from 60,000 gallons to over 1,000,000 gallons per day. The average daily flow dealt with may be taken at about 750,000 gallons.

In the following table are given the average results of analyses made by the Worcester City Analyst of screened sewage (nine samples), and final effluent (twelve samples), from June, 1916, to May, 1917.

Results in Parts per 100,000.

	Screened Sewage.	Final Effluent.	Purification.
Four hours' oxygen absorption ...	3.70	0.56	85%
Albuminoid ammonia	0.76	0.14	82%
Suspended solids	14.3	0.72	—

The final effluent was perfectly clear and colourless and contained very little suspended matter. These results indicate that a high degree of purification is obtained with the production of an entirely satisfactory effluent.

Under normal conditions the compressor speed is 160 r.p.m., which gives a free air delivery of 384 cubic feet per minute and about 20 b.h.p. The working air pressure is nine pounds per square inch. This volume of air employed is equal to only seven cubic feet per square foot tank area per hour, and is inclusive of the air used by the airlifts for returning the sludge to the aeration chamber. Working at a rate of 750,000 gallons per day the air consumption is equal to 0.7 cubic feet free air (actual delivery) per gallon of sewage treated. The electric motor driving the compressor absorbs 16 units per hour, so that at three farthings per unit, the cost at Worcester is equal to thirty-two shillings per million gallons of sewage treated when working at the above rate.

Some little time ago sand drainage beds were constructed to receive the surplus sludge, but the results of their operations I have not been able to ascertain, so it is impossible to say with any certainty what volume of sludge is produced per million gallons dealt with. Experiments carried out by Dr. Ardern, of

the Withington Sewage Works, are just to hand. Dried sludge powdered 1,342 lbs. per 1,000,000 gallons sewage treated.

Up to the present the settlement tanks appear to be the limiting factor in regard to the volume of sewage with which the installation is capable of dealing.

The outstanding feature of this installation is the low air consumption without the assistance of a pulsating air supply. It may be stated that it is not more than one-half the volume employed in the American installations, and it is very considerably less than the estimate based on early investigations.

Dr. Ardern, Chief Chemist to the Manchester Corporation, informed the writer that at present six cubic feet (free air) per square foot tank area per hour is about the minimum air supply they have employed at their Withington Sewage Works.

Dr. Fowler states that, broadly speaking, the activated sludge process consists of three operations:—

(1) A clotting or clarifying action;
(2) A rapid carbon oxidation process;
(3) A final nitrification.

Working with a domestic sewage it is not necessary to push purification to the point of nitrification in order continuously to obtain staple effluents. It necessarily follows that, if ultimate nitrification be not aimed at, the aeration period will be diminished and considerable economy effected.

Whether or no any proportion of the nitrogen in the sludge is due to the presence of nitrogen fixing organisms remains to be demonstrated. At the early stages of the activated sludge process there was considerable discussion as to the best methods of aerating the sewage, and many experiments were tried. If perforated pipes are used there is a considerable waste of air by the creation of large bubbles which do not ensure satisfactory mixing of the sewage and the sludge. The experience gained so far with large scale plants indicates that, despite certain disadvantages, the use of diffusers offers a practical solution of the problem. Owing to the risk of choking the fine pores with oily matter, dust, etc., they were originally regarded with suspicion, but I understand that later and more perfect forms of diffusers have reduced this possibility to a minimum. Trouble was found during some of the earlier experiments at Davyhulme, Manchester, in oil choking the underside of the diffusers. This was due chiefly to the fact that air was drawn from high pressure sources and the oil used had become carbonised, but if air is compressed to not more than about 10 lbs. per square inch, the temperature of compression is not sufficient to alter the nature of the oil, and thus the liability to choke is small, provided the air compressed is clean.

The porous tile diffuser, as compared with any other system of aeration, has the following advantages which fully justify its adoption:—

(1) There are no moving parts in the sewage.
(2) The air is evenly distributed.
(3) The air used for aeration provides also for agitation and circulation.

(4) Less air is used.

To secure the utmost possible economy in air consumption Messrs. Jones and Attwood have patented a mechanical gear whereby a pulsating air supply is automatically obtained. This has reduced the air consumption considerably and given very good results. For example, at Davyhulme, Manchester, a pulsating gear is in operation. The design of the cams at present employed gives a ratio of the time of admission of air to the diffuser to the period of rest of 1 to 2; the actual time of these periods can be varied by regulating the speed of the cam shaft. As a general rule each set of diffusers receives air for five seconds at intervals of ten seconds. The ratio can be varied by substituting cams of a different design.

The next matter to consider is the sludge. Activated sludge differs from ordinary sludge in its physical characteristics and in its ready drainability. It is not gaseous like either Emsher tank or septic tank sludge. In properly aerated sewage the sludge settles to the bottom and the clarified liquor comes to the surface quickly. The liquid separates from the sludge so quickly and effectually that there need be little difficulty in drawing it off from a sludge tank and de-watering from the surface as well as from the bottom. Down to a 90 per cent. water content it drains fairly easily, but, owing to its gelatinous nature, further natural drying is a very tedious matter. The drying of the sludge I will deal with later.

The proportion of activated sludge to the sewage depends on a variety of factors—tank capacity, air supply, character of sewage, degree of purification required, etc. From the various experiments tried in England and America, I think it may be accepted that the volume of sludge should be maintained as low as possible, consistently with adequate clarification. If a high nitrification is desired a greater proportion of sludge will be necessary. The average requirements are from 20 to 25 per cent. of sludge.

One of the most interesting features of the whole process is the conservation in the sludge of much nitrogen which had hitherto been lost. There was, in fact, reason to hope that the value of the nitrogen thus saved in the sludge would pay for a great part, if not the whole, of the process of sewage purification. This great saving of valuable nitrogenous manure is a point of great economic importance. The percentage of nitrogen saved varies from four to six per cent., according to the character of the sewage.

The following average chemical analysis of the activated sludge obtained from the Withington Sewage Works at Manchester will be of interest:—

Chemical Analysis.

Loss on ignition	70.4 per cent.
Mineral matter	29.6 per cent.
Total nitrogen (as N)	6.0 per cent.
Phosphate	4.2 per cent.
Greasy matter, etc.	7.3 per cent.

Gelatine counts have shown a bacterial content of at least thirty million organisms per cubic centimetre. In addition the sludge, by reason of its nitrifying power, must of necessity contain a large number of nitrifying organisms. Dealing with the quantity of sludge per million gallons of sewage one must remember that there is less sludge from a bacterial process than a chemical process. The activated sludge process is a bacterial process, and the resultant sludge per million gallons of sewage treated is about one to one and a half tons dry, but, of course, that depends on the class of sewage and the amount of moisture.

The methods to be adopted for the extraction of moisture, the pressing, drying and conversion of the sludge from what has formerly been regarded as a troublesome and costly nuisance to a welcome and valuable fertiliser, will depend upon the quantity to be treated and the conditions under which it is dried.

The problem of drying or de-watering of the sludge is one where there is large scope for improvements. The writer had the privilege of watching some experiments for drying the sludge carried out by Mr. R. A. Sturgeon, of the Sturgeon Centrifugal Company. The method adopted by Mr. Sturgeon for de-watering is centrifugal force applied without using heat of any description. If heat is applied in the drying process the value of the sludge is immediately diminished, owing to lower percentage of nitrogen. Here, in South Africa, we have the advantage of a good dry climate and bright sunny days, which I think could be taken advantage of and used for drying the sludge. If, for example, the liquid sludge could be run on to an open sand filter, I believe it could be dried very simply and cheap. The cost of drying the sludge in England is thirty-six shillings per ton. I think, with the more favourable atmospheric conditions prevailing in South Africa this cost could be considerably reduced. So far the testing of the fertilising value of the sludge has been conducted on a small scale only, owing to the limited quantity of material available, but when the installations now under way are in full working order trials on a commercial scale will be possible, and it is satisfactory to know that the Board of Agriculture in England is taking an active interest in the matter. To show the availability of the nitrogen in activated sludge, two equal plots, A and B, were prepared near Manchester, A with activated sludge in powder form, B with farmyard manure. Calculating the amount of nitrogen in farmyard manure to be five per cent., activated sludge was added to plot A in quantities containing as nearly as possible the equivalent amount of nitrogen, and in both were set an equal number of seed potatoes. Plot A yielded 150 lbs., and plot B 62 lbs. of potatoes. These experiments were carried out by Mr. Ernest Gaul, M.Sc., of the Manchester University. The writer had the pleasure of seeing the results of many experiments on horticultural plants carried out by Mr. Walter Jones at "The Uplands," Stourbridge, and has obtained a photograph of a pair of azalea plants, one treated with activated sludge and the other untreated. In the one case the soil was top dressed on January

18th, 1917, and the photo taken on March 31st, 1917. The difference in blooms and foliage is noticeable.

The process has been very extensively adopted in England and America, and during the war plants were installed by the Ministry of Munitions, by the United States Red Cross, by the Admiralty, and others. In England plants are installed at Baguley, Davyhulme, Worcester, Stamford, Aintree, Blackpool, Withington, St. Albans, Tunstall, Moreton, Harpenden, Witney and Birmingham. Also abroad they are installed at Holte and Burmeister, Denmark; Jamshedpur and Sibpur, India; and last, but not least, De Beers, Kimberley, South Africa. At Milwaukee, in America, they are spending £1,000,000 to instal the new process, which will treat eighty-five millions gallons per twenty-four hours d.w.f. I might mention that the Royal Sanitary Institute have just granted their Silver Medal, their highest award, to Activated Sludge, Ltd.

Before concluding, I think the paper would be incomplete without comparing the question of cost, both capital and working charges, and I will take the figures given by Mr. W. M. Makepeace, Borough Sewage Engineer, Stoke-on-Trent, in his report of April, 1920. For comparison he has taken a population of 50,000 with a dry weather flow of one and a half million gallons. The cost of a Bacteria Plant to deal with this population where pumping would be necessary is £125,000, and the working charges for the year would be £6,800. The capital cost of an activated sludge plant on the same basis would be £85,000, and the working charges calculated from the air consumption required to deal with three times the d.w.f. as sewage, and three to six times as storm water, together with making provision for dealing with the sludge and without taking any credit for its market value as fertiliser, is £4,372. You will note that there is a saving capital expenditure of £40,000 and an annual saving on working costs of £2,427. Then you have the revenue from the sale of sludge, which has not been taken into account.

The following is a comparison analysis of a raw sewage and final effluent, one treated by activated sludge and the other treated on first and second contact beds. Both processes were supplied from the same sewer.

RESULTS IN GRAINS PER GALLON.

	Activated Sludge Process.		First and Second Contact, Bed Treatment.	
	Sewage.	Effluent.	Sewage.	Effluent.
Four Hours' Oxygen Absorption...	6.83	1.04	6.44	2.83
Percentage Purification	—	85%	—	62%
Free and Saline Ammonia ...	1.98	0.01	0.12	1.82
Albuminoid Ammonia	0.59	0.10	0.66	0.45
Nitrite and Nitrate ... ... (In terms NH_3)	—	0.37	—	0.03

In conclusion, I wish to express my sincere thanks to Messrs. Jones and Attwood, Ltd., for the privilege of visiting all their works and inspecting their experimental tanks while experiments were proceeding, and also to Dr. Ardern, Chief Chemist, Rivers Department, Manchester, who always placed all information at my disposal. I hope I have given sufficient evidence in this paper without postulating to prove the great possibilities of the Activated Sludge Process of sewage purification, and that some town in South Africa will soon have a plant installed and reap the benefit of the experiments carried out in England. I think the process is particularly adapted to large inland towns in tropical countries. As I have stated, the cost of drying the sludge is a very big item in England, and can very easily be done out here for at least half the cost, which is a very great consideration, and thereby convert your sewage scheme into a very profitable concern.

ON THE MECHANICAL ANALYSIS OF SOIL CONTAINING HEAVY MINERALS.

BY

B. DE C. MARCHAND, B.A., D.Sc.,

Division of Chemistry, Union Department of Agriculture.

Read July 13, 1921.

The mechanical analysis of soils is chiefly of value as a basis for the correlation of soils of known properties with others regarding which information is sought. It is obviously essential that the basis of comparison should be common to the soils compared. For this reason the comparison of soils differing widely as regards their content of such constituents, as calcium carbonate or organic matter, which, apart from size of particles, modify the texture, cannot be made unless the relative quantities of such modifying constituents be taken into account. When the proportion of such modifying constituents is large mechanical analysis is almost worthless as a basis of comparison.

Now in the mechanical analysis of mineral soils, that is of soils to which the method may safely be applied, an important fundamental assumption is made; that is, that the relation between the weight and the volume of the soil particles is constant for all particles of whatever size and for all soils. In the great majority of cases this assumption is justified. We have, however, recently examined a series of soil samples, all belonging to the same type, which differ considerably in density from the average for normal soils and also, to some extent, from one another.

In the case of the coarser particles, which are usually separated by means of sieves, the limiting size is determined by the

sieves employed. The percentages of these, and also of the smaller fractions, are determined by weight. Now in the soils referred to each mechanical fraction consisted to a considerable extent of iron ores, chiefly magnetite. The specific gravity of the particles separated by means of a magnet from two different soil samples was found to be 4·6. The normal density of soil is approximately 2·6. It is obvious that a given number of magnetite particles of any one size will influence the texture of the soil to exactly the same extent as the same number of, say, quartz particles of the same size, yet the weight of the former will stand to the weight of the latter as 4·6 : 2·6. In other words the common basis of comparison is removed and correlation in the ordinary way is of no value. If the soil were homogeneous this difficulty would not arise, since percentages by weight would then accurately represent percentages by volume, but since soil is an extremely heterogeneous substance, and the soil which forms the subject of this note particularly so as regards the relations between the weight and the volume of the component particles, the question must be given consideration.

The finer particles are grouped according to size by elutriation or sedimentation. The latter process only will be considered, but the remarks made may be applied, suitably modified, to elutriation processes.

Hall,* whose method of mechanical analysis is used in the laboratory of the Division of Chemistry, has shown that the limiting diameters of particles separated by sedimentation are in agreement with the expression,

$$v = \frac{2ga^2(\sigma - \rho)}{9\eta}$$

deduced from the work of Stokes for the velocity of a spherical particle falling through a viscous medium. (v = the velocity of the falling particle, a its radius taken as a sphere, σ its density, ρ the density of the medium, and η the coefficient of viscosity of the medium.) From this expression we get for any given velocity of a particle falling in water

$$a = \frac{\kappa}{\sqrt{\sigma - 1}}$$

as the relationship between the limiting radius of the particle and its density. Thus, the limiting size for magnetite particles of density 4·6 is approximately two-thirds of that for quartz particles of density 2·6. That is, each mechanical fraction in the case of a soil containing the heavy mineral (magnetite) will contain particles of the heavy mineral of smaller size than the limiting or smallest size for the corresponding fraction of normal soils. Micro-

*Hall, A. D. (1904), "The Mechanical Analysis of Soils and the Composition of the Fractions resulting therefrom." Jour. Chem. Soc., LXXXV, 950.

scopic examination of the fractions showed the presence of particles of magnetite smaller than the smallest quartz grains. It has been noted by Stadler* in advocating grading analyses by elutriation of mill products that an error in such analyses is occasioned by the presence in Rand ore of a small percentage of pyrites.

In Table I the mechanical analyses of some samples of the magnetite soil are given, together with certain other data. Attention is directed chiefly to the differences between the percentages by weight and by volume of fine gravel and sand taken together in the case of those samples containing much magnetite. A method for reducing these soils to a common basis was sought without much success. The chief reason for this non-success lay in the practical impossibility of effecting a rapid and reasonably accurate separation of the soil into heavy and normal particles.

The percentages by weight of particles greater than 0·2 mm. may be corrected to agree fairly well with the percentages by volume by calculating the quartz equivalent of the magnetite particles, taking the density of the latter as 4·6, or, by calculating the quartz equivalent of the particles separated by Thoulet's solution of density 3, taking the density of such particles as 3·5. Such corrections are shown in Table II.

The whole question is complicated by the very nature of the heavy mineral present. The products of the weathering of the magnetite, hydrated ferric oxide, have a very marked flocculating effect on clay, thus introducing another texture-modifying factor. Had the heavy mineral been one which could have influenced texture in only one way, say, zircon, an attempt might have been made at exact mechanical analyses by first effecting the separation in the usual way, then separating each fraction into two parts by means of a heavy solution and finally putting the heavy portions through the sedimentation process suitably modified so as to obtain fractions between the same size limits as those obtaining for normal soils. Such an analysis would be terribly tedious and would be of doubtful value as it is impossible to assign an exact quantitative value to the degree in which any particular mechanical fraction influences the soil texture. It is essential, however, in dealing with soils which contain abnormal quantities of heavy minerals, that the proportion of these be taken into consideration when basing a judgment on the results of the mechanical analyses, in much the same way as the percentages of calcium carbonate and of organic matter are used to modify the picture drawn by the mechanical analyses. In this connection it may be noted, that soil scientists in the United States frequently omit all mention of such modifying factors as calcium carbonate and organic matter, and that their example has been followed in this country.

---

*Stadler, H. (1913), "Grading Analysis by Elutriation." Transact.. Inst. Mining and Metall. XXII, p. 686.

Table I.

Sample No.	Normal size	3534	3537	3614	3658	3661	3664	3670	3680	4881
		%	%	%	%	%	%	%	%	%
Fine Gravel	1-3 m.m,	5·2	2·9	9·9	4·0	6 2	6·7	10·1	5·0	3·6
Sand	0·2-1 ,,	25·2	15·7	46·5	33·2	23·5	31·2	19.6	35·0	20·6
Fine Sand	0·04-0·2 ,,	12·6	11·3	—	15·9	—	12·9	10·2	18·7	12·8
Silt	0·01-0·04 ,,	5·6	6·9	—	3·8	—	4·0	4·7	6·2	4·6
Fine Silt	0·004-0·01 ,,	6·3	8·4	—	4·1	—	4·7	5·1	4·1	5·6
Very Fine Silt	0·002-0·004 ,,	5·1	6·2	—	2·3	—	2·8	3·5	2·9	2·5
Clay	0·002 ,,	30·2	34·3	—	29·0	—	30·3	37·1	20·9	38·3
Moisture	...	3·1	3·8	2·4	2·0	2·9	3·0	4·0	2·1	2·9
Loss on ignition	...	7·0	8·9	3·6	4·7	6·3	6·2	7·1	4·8	7·2
Calcium Carbonate ...	...	0·21	0·19	—	—	—	0·24	0·27	—	0·23
Magnetite—										
in Fine Gravel ...	...	3·4	0·2	7·6	1·2	0·5	3·8	9·9	0·3	0·5
in Sand	...	6·5	0·9	29·8	4·4	2·0	14·7	14·8	1·1	1·9
Heavy Minerals (sp. gr. 3)—										
in Fine Gravel... ...	...	4·0	1·1	8·8	1·3	1·8	6·6	9·9	1·0	0·5
in Sand	...	13·5	4·1	39·7	5·5	8·7	20·8	16·3	6·2	4·1
Specific gravity of Soil ...	..	2·8	2·8	3·3	2·8	2·7	3·0	2·9	2·9	2·7

Table II.

Fine Gravel and Sand (0·2 mm.—3 mm.)

Sample No.	Percentage by weight a	Percentage by volume b	"a" corrected for Magnetite Sp. gr. 4·6 c	"a" corrected for heavy minerals Sp. gr. 3·5 d
3534	30·4	26·5	26·1	25·9
3537	18·6	16·9	18·1	17·3
3644	56·4	48·3	40·1	43·9
3658	37·2	34·8	34·8	35·5
3661	29·7	28·4	28·6	27·0
3664	37·9	31·5	29·9	30·8
3670	29·7	19·2	19·3	23·0
3680	40·0	40 1	39·4	38·1
4881	24·2	23·4	23·2	23·0

CONDENSED MILK IN SOUTH AFRICA FROM THE CHEMIST'S POINT OF VIEW.

BY

A. A. Kloot, B.Sc., F.I.C., and Leslie Hyman.

Read July 13, 1921.

Sweetened condensed milk, or just condensed milk, is the whole milk of the cow evaporated to a more or less definite consistency and sweetened with cane-sugar. The latter serves the double purpose of sweetening and preserving.

The aim of the manufacturer should be to produce an article which, when diluted according to instructions, gives a whole milk as produced by the cow plus the sugar added. This is not generally attainable as the finished article invariably has a flavour of its own, due to the cooking process through which it has gone. Apart from slight changes in the composition of the protein matter, made up condensed milk is practically identical with sweetened fresh milk. It has been demonstrated that the water and fat soluble vitamine content is not affected by the process of manufacture; though it is probable that the anti-scorbutic vitamine is destroyed to some extent.

A brief outline of the manufacturing process may now be given. First a quantity of cane sugar solution is made with a portion of the milk. Best refined sugar is advisable. The sugar solution is then united with the main portion of the milk, and the whole passed through a pre-heater into a vacuum pan. The latter must be of copper on account of the action of weaker acids. A vacuum is raised, and the milk is heated by means of a copper steam coil in the bottom of the pan.

It is necessary to control the temperature very carefully, as exceeding a temperature of 140° F. is likely to cause faults in the milk. As the water evaporates from the milk fresh milk is automatically sucked into the pan until the batch is complete. The desired consistency is shown by a gravity of 1·28—1·30, but the experienced worker knows instinctively when to "strike" a batch.

The condensed milk is then run into cooling pans where it is well stirred, then to a scale for weighing, and finally to the storage tanks. From here the milk passes to an automatic tin-filler, and sealing, labelling and packing complete the process.

This description is necessarily short, but it should be remembered that at least nine different defects caused by unscientific management are possible, all or any of which are sufficient to render the milk unmarketable. Most important is "grittiness." This is most often due to precipitation of milk sugar. This is readily distinguished from cane sugar under the microscope.

Milk sugar at ordinary temperatures dissolves in six parts of water. Condensed milk contains 12 to 15 per cent. of milk sugar and 26·5 per cent. of water. This means one of milk sugar

in two of water. Evidently, then, properly prepared condensed milk contains milk sugar in super-saturated solution; any favouring condition will precipitate the lactose as gritty crystals.

The chief factor which makes permanent super-saturation possible is the high viscosity of condensed milk due to casein and cane sugar. Small portions of undissolved sucrose in the original solution, overheating, too rapid cooling, or even excessive stirring, may lead to grittiness.

Another important defect is "settling." This means separation of cane sugar. It is almost impossible to get a condensed milk containing no sugar crystals. With proper attention to details, however, these do not separate out, and it will be apparent that viscosity plays a big part in the defect. If about 2·5 parts of fresh milk have produced 1 of condensed milk, the density is usually correct. Higher or lower density favours settling.

For the same reason fat content is important, and of course the proper proportion of sugar must be adhered to.

Lumpy, buttony, rancid, and cheesy milks may all be produced from good milk and sugar if scientific control is lacking.

Every properly equipped factory has a laboratory. In this both raw materials and finished product are tested, and defects ever likely to crop up are investigated. Batches of fresh milk are examined for total solids, fat and acidity. Milk excessive in fat is separated; the milk of high acidity is rejected. The reductase test for micro-organisms is generally sufficient, but occasional controls for tubercle bacillus should be made. The total solids give a simple control over the output of the factory.

For the analysis of the finished product, 40 grammes of milk are dissolved in water and made up to 100 c.c. 5 grammes are weighed into a platinum dish containing ignited asbestos, and total solids and ash determined. The protein matter is determined by multiplying nitrogen estimated by Kjeldahl by 6·38, or precipitation by copper sulphate may be employed.

For fat 11 c.c. of the solution are precipitated with 5 c.c. of copper sulphate. Precipitated casein and fat are separated from the sugar solution by means of the centrifuge. After thorough washing these are decomposed by the addition of 13·75 c.c. sulphuric acid and 1·25 c.c. amyl alcohol. After further centrifuging the Leffmann-Beam bottles in which these operations are carried out are heated to 66° C., and the fat in the neck of the bottle read off. The number of the graduations multiplied by 0·4 gives the percentage of fat.

For sugars, 25 c.c. of the milk solution are placed in a large test tube with 19·5 c.c. of water and 1 c.c. of mercuric nitrate. After centrifuging the sugar solution is filtered off and read direct in a 2·2 decimetre tube. 20 c.c. are then inverted by boiling for ten minutes, and then are made up to 25 c.c. The reading of this inverted solution multiplied by 5/4 gives B in the formula. The direct reading by the polariscope is A of the formula. The formula is:—

$$S = \text{Cane Sugar} = \frac{A - B}{45.4} \times 100$$

$$\text{Lactose} = \frac{A - 0.3315\ S}{26.44} \times 100$$

If no cane sugar is present

$$\text{Lactose} = \frac{A}{26.44} \times 100$$

If no polariscope is available the following method has been found by one of us to give satisfactory results. The milk solution is curdled with acetic acid, and, after filtering, lead acetate is added. Excess of lead is removed by sodium sulphate, and the lactose estimated by direct reduction of Fehling's solution. After inversion the total sugars can be estimated.

In addition physical constants such as viscosity and colour tests, and sterilisation standards are carried out in the laboratories of the big American condensed milk factories.

It will be apparent from these examinations if the milk will "keep" for a long period (in airtight tins of course), and, of equal importance, whether they will pass the legal standards of the different States.

While on this subject we must refer to the inconvenience and unfairness of having different standards in different Provinces, and in different countries for that matter. Sweetened condensed milk in Natal must contain 31 per cent. milk solids, 28·5 per cent. of which must be fat. No extraneous matter except sugar is permitted. So far as we know, different percentages apply in the other three Provinces of the Union. In the United States standards vary from 24·5 to 34·3 per cent. solids, with corresponding amounts of fat. It is surely time that international standards for milk, condensed milk, and essential foods were laid down.

In the writers' opinion minimum and maximum fats and total solids should be abolished as regards condensed milk. The main criterion as to suitability for sale should be whether or not the sample is prepared from whole fresh milk (this, of course, in addition to its wholesomeness at the time of sale). Original fresh milk should be of the standard 11·8 per cent. total solids and 3·3 per cent. of fat. These figures may not be the best, but figures to guide the analyst should certainly be provided in a schedule. Relation of fat to protein matter is a very important indication of skimming. It is very seldom that the proportion fat: protein is less than 1 : 0·82 in condensed milk, and an experienced analyst will make very few mistakes in his conclusion.

The law should further compel the manufacturer to state on each tin to what extent the article must be diluted with water in order to bring it to the standard of fresh milk laid down. The current instructions on tins are to mix with from two to four parts of water, or to mix water until the desired consistency is obtained. These instructions are not only vague, but definitely harmful where young children are being fed with condensed milk.

As regards the commercial side of the proposition little can be said here. In 1920 the cost in South Africa of milk and sugar to produce one case of 48 tins of condensed milk was about 15/-, against 6 dollars 38 cents in the United States. Even allowing for variations in exchange it will become evident that South Africa has a huge new industry open to it.

Both the writers have had considerable experience with condensed milk. It is not too much to say that condensed milk manufactured recently in South Africa can compete as regards quality in the world's markets with the best imported brands.

It is only possible here to mention products such as milk powder, casein and various other by-products, the manufacture of which would naturally grow up with the main industry.

Finally the tremendous effect such an industry would have on the pastural development of South Africa must not be overlooked. At the present time owing to long distances from town the only way for farmers to dispose of milk is to separate and sell butter-fat. This entails labour and little profit, and little inducement is given to the farmer to increase production. Establishment of condensed milk factories which can afford to pay the farmer a remunerative price and receive his output at all times must make for increased and more profitable dairy farming in the Union.

THE GENUS *PASSERINA* AND ITS DISTRIBUTION IN SOUTH AFRICA.

BY

D. THODAY, M.A.,

Professor of Botany, University of Cape Town.

Read July 15, 1921.

Abstract.

In the course of investigations following upon the observation communicated at Bulawayo last year, that the leaves of *Passerina filiformis* and of some other plants with ericoid leaves close the leaf-grooves in time of drought, different forms of Passerina have been met with which could not be satisfactorily identified either by means of the "Flora capensis" or by comparison with herbarium specimens recently identified at Kew. A careful perusal revealed more than one instance of inconsistency, and it has appeared necessary to attack the classification of the genus *de novo*. Through the courtesy of those in charge of the Herbaria of South Africa all the available specimens have been examined and compared. Thirteen forms have been recognised, all of which can be distinguished from one another with certainty, the available material providing no intermediates. One of these forms, found in marshy

spots on the Cape Flats, usually along with *Dovea tectorum*, appears not to have been collected before.

Additional evidence of the new classification is afforded by the consistency of the distribution of those widely spread, in contrast with the confused distribution recorded in the "Flora Capensis."

Until it has been possible to examine the material in the European Herbaria names cannot be assigned with certainty, though some are here employed tentatively, in conformity with their current application. The widely distributed species are five in number, each with a well-defined habitat and range. *Passerina filiformis* is the common species of the maquis of the South-West Cape; *P. rigida* is characteristic of exposed sand dunes near the sea from Muizenberg to Durban and beyond; *P. ericoides* is the species of high altitudes, extending on the Drakensberg and associated high mountain ranges from the Eastern Province to Umtali; the species called by Natal botanists *P. filiformis* but distinct from the south-west species is found in the outer fringes of the scrub and forest in Natal and in the neighbouring regions to the south, and also at the north-west part of the Cape Peninsula, especially on the mountain buttresses; finally a species, which is probably Meisner's *P. rigida* var. *truncata*, extends from Tulbagh northward along the western ranges, and into Little Namaqualand in and around the areas characterised by a flora of the south-western type.

The remaining forms have a more restricted distribution; some are very local or rare. *P. falcifolia* is apparently confined to the forest region of the Outeniqua and Zitzikamma Mountains, where in the forest fringes it reaches nearly twenty feet in height. In the Cape Peninsula five forms occur. Each of these has its characteristic habitat. *P. filiformis* is found on well-drained sandy or gravelly soil on the Cape Flats and the mountain slopes. The form which has been confused with it is apparently confined to the north-west corner, on the mountain buttresses, and also on the western and north-western slopes on granitic soils of closer texture. *P. rigida* is confined to the exposed sand dunes east of Muizenberg, where it grows beside *Chymococca empetroides*. A fourth species is found on deep drift and farther from the sea; while a fifth, not previously collected, is characteristic of brack marshes and vlei margins on the Cape Flats.

So far the data suggest forcibly that habitat is a factor of prime importance in the distribution of the species. Further research is required to determine what light the study of the genus can throw on general problems of geographical distribution. A peculiar anatomical feature of the leaves, an account of which in *P. filiformis* is in course of publication,* is of significance here, namely, the "wandering" of fibres laterally from the bundles between the outer epidermis and the palisade tissue in certain species. The presence of this feature in *P. rigida* indicates a close relationship between this species and *P. filiformis*.

* Since published in "Annals of Botany." XXXV., 1921, p. 585.

ON SOME FUNGI FROM THE AIR OF SUGAR MILLS AND THEIR ECONOMIC IMPORTANCE TO THE SUGAR INDUSTRY.

BY

PAUL A. VAN DER BIJL, M.A., D.Sc., F.L.S.,
Professor of Mycology, University of Stellenbosch.

Read July 12, 1921.

Elsewhere I dealt with various fungi and bacteria isolated from sugar*, and have indicated the part these micro-organisms play in the "sweating" and the deterioration of sugar during storage. Following up this investigation it appeared desirable also to make a micro-biological analysis of the air of a sugar mill and of a sugar store above the mill. For this purpose a series of petri-dishes with a suitable medium was exposed for 15 minutes in the above-mentioned places and the organisms which subsequently developed in the petri-dishes noted. A number of bacteria and fungi developed, but only the fungi were preserved. This phase in the investigation of sugar deterioration has only recently been begun, so that the number of fungi will, in time, probably be considerably augmented.

The chief fungi found were *Penicillium spp.* and *Aspergillus spp.*, and some of them have already previously been isolated from sugar from warehouses in Durban and were described in the publications† cited previously.

The undermentioned were amongst the fungi found in such a micro-biological analysis of the air of a mill and of a sugar store above the mill:—

Cladosporium sp. A similar fungus from sugar has also been isolated by me and has been shown to be capable of inverting sucrose.

Penicillium divaricatum. This fungus also has been isolated by me from sugar, and it is amongst the fungi dealt with in "Studies on some fungi and the deterioration of Sugar." It is a fungus frequently met with in sugar in Durban.

Aspergillus flavus. Though I have isolated several species of *Aspergilli* from sugar I have not found this one. It has been recorded from sugar by Amons from Java, and its existence in the air of sugar mills here is hence of interest.

---

*van der Bijl, P.A. "Preliminary Studies on some fungi and bacteria responsible for the deterioration of S.A. Sugars." Dept. Agric., Science Bulletin No. 12, 1920.

†van der Bijl, P.A. "Studies on some Fungi and the Deterioration of Sugar." Dept. Agric., Science Bulletin No. 18, 1920.

Aspergillus parasiticus. This *Aspergillus* also was not found in my culture from sugar, but Miss Church, of the United States Department of Agriculture, informs me it has been isolated from sugar by Kopeloff, in Louisiana.

Aspergillus repens-glaucus group. Members of this group are amongst the Aspergilli most frequently met with in sugar here, and strains of them are considered in both of the publications cited. They are also recorded from sugar from Java and Louisiana.

Monilia spp. Browne mentions two species of Monilia from Cuban raw sugar and records the result of their growth in raw sugar solutions. So far I have not come across *Monilia* in isolations from sugar, and the one found in the air of a sugar mill is *Monilia sitophila*.

In addition to the above fungi there were present three further Penicillium spp. and a member of a group of Penicillia common in soils and designated by Chas. Thom and Miss Church in an article by O. A. Pratt as the "Soil series Penicillia."

The fungi above enumerated from the air of a sugar mill belong to the groups which have been shown to be of considerable economic importance to the sugar industry as they are, under favourable conditions, amongst the more important of the micro-organisms responsible for the deterioration of sugar in storage, a problem which is at present receiving the attention of scientific workers in all the great sugar producing countries. It is with pleasure we acknowledge the assistance given us in our investigations by Dr. Chas. Thom and Miss Margret Church, both of the United States Department of Agriculture.

THE PLANT SUCCESSION IN A TYPE OF MIDLAND TREE VELD IN NATAL.

BY

R. D. AITKEN, M.Sc.,
Natal University College.

With Plates II, III, and 1 Map.

Read July 12, 1921.

I. INTRODUTION.

Attention has often been drawn to the wide areas of country in South Africa which are covered by Tree Veld, and a preliminary division of this type of vegetation into several formations has been attempted (3)*, *e.g.*, Acacia or Thorn Veld of the Eastern side; Protea Veld of the higher altitudes; Bush Veld of the Transvaal. There is no doubt, however, that the subdivision of climax associations can be carried still further, and this becomes particularly

*The numbers refer to the list of references at the end of this paper.

clear when a smaller area is studied more intensively. Thus, in Natal alone, quite a number of distinct types of Tree Veld, as well as local variations of each type, occur. Of these by far the most extensive is the Thorn Veld, in which the succession has already been analysed in detail by Professor Bews (4). Other types which have been briefly described by the same author are the Protea Veld, the Rocky Scrub with *Greyia sutherlandi* dominant, and the Leucosidea scrub of the Drakensberg (5); the Rocky Hillside type of the Midlands (2); and the various types of Tree Veld of the Coast-belt, *e.g.*, Ilala-Palm Veld and hygrophilous Tree Veld (6). Very often these types occur mixed with the more xerophytic Thorn Veld, but usually they are quite distinct. A good example of this is the Ilala-Palm Veld, which covers large areas of the Zululand coast-belt (7). Where it occurs in proximity to Thorn Veld the palms often extend for some distance into the latter, particularly if the thorn trees are very scattered.

All these types of Tree Veld, though differing greatly from one another in their composition, have one remarkable feature in common, a feature which is quite unique—the invasion of grassland by trees in the first stage of the succession. Tree Veld has usually a very characteristic, park-like appearance, due to the formation of scattered clumps of trees and bushes in the grassland. The actual pioneer in the formation of these clumps varies according to the type of climax association, but is always a tree. In some cases the succession proceeds no further than this first invasion of the grass-veld, *e.g.*, Ilala-Palm Veld, but as a rule other species succeed the pioneer and grow up in its shade, forming the mature clump. The only detailed account of the complete process so far given is that of Professor Bews on the succession in the Thorn Veld (4). Yet in view of the widespread occurrence of Tree Veld in South Africa and of this unique feature in its establishment, it is very desirable that as many facts as possible should be gathered with regard to the various types, and the succession in each.

The present paper is intended to give an account of the succession in a type of Tree Veld, which may be termed a Cussonia-Combretum association. It shows some resemblances to the Rocky Hillside type, already mentioned, from which, however, it appears to be quite distinct. It occurs on the northern slopes of Signal Hill, situated just outside Maritzburg proper and to the south-west of the town. (Pl. II, Fig. 1.) No details can as yet be given as to the distribution of this type, but it is probably fairly common on hillsides throughout the Midlands.

II. Topography and Climate.

A panoramic view of practically the whole area studied can be very well obtained from any point near the summit of the hill. From such a vantage point one looks down upon an undulating stretch of grassland sloping gently upwards. Almost through the

centre of this runs a shallow valley well filled with trees. (In order to simplify the description this valley is termed the "central valley" throughout the remainder of this paper.) A very noticeable feature is the almost complete absence of trees to the west of this valley. Numerous clumps of trees occur in the grassland to the east, but with one or two exceptions there are none at all to the west. The accompanying map of the "central valley" and the adjacent hillsides shows this very clearly.

SIGNAL HILL, MARITZBURG.

Showing distribution of clumps on slopes adjacent to "central" valley.'

The numbered clumps are those described in detail in the paper.

A is a small *Acacia ataxacantha* growing in the open.
C is a small clump in which *Clerodendron glabrum* is the pioneer.

West of Signal Hill proper is a very deep valley with steep sides; a smaller valley ("valley A"), rising near the head of the "central valley," passes into this. Between the heads of "valley A" and the "central valley" are found the only clumps which occur to the west of the latter. Still further to the west is a line of low hills cut into by deep valleys, but trees are almost entirely absent from the steep sides of these. The slope immediately below our point of vantage, and one further to the east, are the only ones in the neighbourhood on which scattered clumps of trees can be seen.

Turning now to the east, one notices another valley ("valley B"), and beyond this the hillside just mentioned. Streams of water flow through most, if not all, of these valleys, and in some cases they have cut deeply into the bed of the valley, forming rather deep and narrow dongas.

The slopes on which the tree veld occurs face almost due north, and consequently receive very strong sunlight throughout the day. The deep narrow valleys to the west receive a much shorter period of illumination each day, and this may explain the absence of tree veld from the adjacent slopes. Exact measurements of insolation have not been made, but the writer has often noticed that at this time of the year the slopes on which the trees occur are in full sunlight until about five o'clock, whereas the western slopes of the deep valleys pass into shade at about half-past three or four o'clock.

Frosts are probably rare on the hillside, though they are recorded at the Botanic Gardens just below. Even here there is seldom more than 5 degrees of frost, the record of 11 degrees last year being the lowest known for twenty years. The Gardens are, however, situated at the lowest level in the neighbourhood, and the temperature will be appreciably higher on the slopes investigated. The fact that bananas and pineapples are successfully grown at about the same level on a neighbouring hillside indicates the almost complete absence of frost.

III. Type of Grassland Invaded.

The dominant grass all over the hillside is *Aristida junciformis*, which has almost entirely replaced *Themeda* (*Anthistiria*) *triandra*, probably on account of repeated grass burning. Other grasses present are *Andropogon hirtus* (subdominant in places), *A. schoenanthus* var. *versicolor*, *A. pertusus*, *A. intermedius* var. *punctatus*, *A. eucomis*, *Eragrostis chalcantha*, *E. brizoides*, *Panicum serratum*, *Sporobolus indicus*, *Tricholaena rosea*. Scattered throughout the veld are numerous associated plants, but they were not in flower during the period of investigation, and consequently lists of these have not been compiled. Mention must, however, be made of the occurrence in isolated patches of *Aloe saponaria* and of *Vangueria* sp., the patches covered by the latter being as a rule the more extensive. *Eugenia albanensis* is also fairly common.

IV. Bases of Colonisation.

The main base of colonisation for the greater part of the area under study is the shallow "central valley." This is about 800 yards long from the head to the railway line which forms the lower boundary of the area investigated. Near the head is a spring from which a small stream of water flows through the valley. The western side is somewhat steeper than the eastern, which is broken by two or three depressions, tributary to the valley itself. The valley is well stocked with trees, of which the following is an almost complete list:—

Combretum kraussii, Ficus capensis, Cussonia spicata, Zizyphus mucronata, Moesa rufesceus, Clerodendron glabrum, Fagara capensis, Gymnosporia buxifolia, Erythroxylon monogynum, Royena pallens, Dombeya rotundifolia, Halleria lucida.

The trees are named roughly in the order of their abundance in the valley. They occur principally on the sides of the valley and not close down to the stream, though *Moesa rufescens* is most plentiful near the spring at the head of the valley. The trees tend to grow in clumps, which become larger and denser as one proceeds up the valley. In each clump one can usually find the oldest tree in the centre, generally one of the first three in the above list, surrounded by a number of younger trees. Straggling over the clumps are numerous climbers such as *Asparagus* sp., *Rhoicissus cirrhiflora, Rubus pinnatus, Clematis brachiata, Smodingium argutum, Mikania scandens* (?). *Plectronia spinosa* is common in all the clumps, growing in the spaces between the trees.

As will be seen from the list given above, the two commonest trees are *Combretum kraussii* and *Ficus capensis.* Of these the latter is found principally towards the head of the valley, and usually well up on the sides. The former is commoner lower down and grows nearer the stream.

Numerous shrubs and herbs occur, growing either in the open or round the edges of the clumps. The following is a list of those in flower at the present time (July, 1921):—

Teucrium africanum, Phytolacca sp., *Lantana camara, Solanum nigrum, Berkheya* sp., *Buddleia salviaefolia, Leonotis leonurus, Artemisia afra,* and one or two Acanthaceae.

A second base of colonisation is the eastern valley (valley "B"), which is rather deeper than the one just described. It is also traversed by a stream of water, which has cut a deep, narrow channel through the bed of the valley. The vegetation in this valley resembles that in the one just described, except that the trees grow much closer to the stream and do not form clumps except higher up on the sides of the valley. This valley contains in addition to the trees listed for the "central valley" *Acacia horrida* and a few others.

V. Migration from the Valleys.

Migration from the bases of colonisation appears to have taken place principally in an eastward direction. This is particularly clear in regard to migration from the "central valley," since, as previously mentioned, the veld west of this is practically devoid of trees except for a few clumps near the head of the valley. With regard to these it is quite feasible to assume that they have been formed by eastward migration from "valley A" rather than from the "central valley" itself. That migration from "valley B" has also been in an eastward direction is shown by the facts that though clumps of trees occur on both sides of the valley they are larger, more numerous, and extend to a much greater distance on to the hillside on the east.

The reason for this eastward migration is somewhat difficult to determine. That it should be due to prevalent winds appears improbable since most of the species which occur in the open, and notably *Cussonia spicata*, have their seeds distributed by birds. The principal exception in this respect is *Combretum kraussii*, whose seeds are wind distributed. A closer study of the migration from the "central valley" seems to throw some light on the problem.

On the eastern side two fairly well-marked depressions pass into this valley, which itself branches into two just above the spring, one branch passing towards the east, the other towards the west. Surveying the whole area from a vantage point near the hill top, it is clear that migration has proceeded along these tributary depressions and through the branches at the head of the valley. Three avenues of clumps can be traced eastwards from the valley, one along each of the depressions, and a third through the eastern branch at the head. A short line of clumps has also been formed along the western branch. These features of the migration are illustrated by the accompanying map. A line of clumps has also been formed through the head of "valley A," and passes above those from the "central valley." The absence of any other lines of migration from this "valley A," which contains the same trees as the central valley though fewer of them, and the absence of any tributary depressions passing into it is suggestive.

Migration from "valley B" has not proceeded along quite such definite lines as from the "central valley," probably because there are no clearly marked depressions on the eastern side. This side, however, is not nearly so steep as, and is much moister than, the other. In fact, the eastern side is quite swampy in parts and a small stream flows down it into the main stream.

These observations suggest an explanation along the following lines:—The particular type of Tree Veld under consideration is much more mesophytic than the commoner Thorn Veld (as indeed is shown by its composition), and is less able to withstand grass fires. At the same time the trees composing it are strong light demanders. Ordinarily they are confined to shallow valleys, where they obtain plenty of moisture, and are sheltered from the full

effects of grass fires. The eastern slopes of the valleys under consideration in this paper are considerably moister than the western, probably owing to the dip of the underlying rocks, and consequently migration on to these slopes has been possible. In the case of the "central valley" the long tributary depressions are not only moister, but serve also to provide some shelter against grass fires.

Further evidence of this eastward migration is afforded by the fact that the largest and thickest clumps occur nearest to the valley, the smallest ones furthest east. This does not, of course, hold absolutely, since each clump may act as a fresh base of colonisation, and one often finds small clumps starting close to much older ones.

VI. The Formation of Clumps.

Outside the valleys the chief pioneer in the invasion of the grassland is *Cussonia spicata*. Unfortunately owing to continual grazing and repeated grass burning not many young clumps are to be found, but in those which occur Cussonia is the most frequent pioneer. There is some evidence, principally from one or two of the older clumps to show that occasionally *Clerodendron glabrum* and *Combretum kraussii* may act as pioneers. In most of the mature clumps *Cussonia spicata* is found in the centre, and is unmistakably the oldest tree present, though its place is sometimes taken by one of the other two trees just mentioned.

The earliest stage of the succession, noticed by the present writer, was a young Cussonia, probably not more than two years old, growing right out in the open veld at a considerable distance from the valley. Alongside it was a young *Ficus capensis*, but, since this does not occur in any of the mature clumps in the open, it will probably be killed out eventually. There seems no reason for supposing that the seeds of the pioneers only are successful in germinating in the open veld, and many of the seedlings may even survive for a year or two, though they are eventually killed, probably owing to the intense illumination to which they are subjected. The pioneers differ in their ability to withstand this and to grow and thrive in their exposed situations in the open veld.

Once the pioneer is firmly established other species soon follow and grow up in its shade. Amongst the earliest arrivals is *Ehretia hottentotica*. Where Cussonia is the pioneer it is soon followed by Combretum and Clerodendron. Later arrivals include *Zizyphus mucronata* (always found at the edge of the clump), *Fagara capensis*, *Clausena inaequalis*, *Euclea* sp. (probably *ovata*), *Dombeya rotundifolia*, and a few others. Shrubs such as *Plectronia spinosa* appear quite early in the succession, and climbers very soon grow up over the clump.

In most of the clumps at the lower levels the succession proceeds no further, and the result is the formation of a small group of trees usually with a clear space in the centre. (See Pl. III, Fig. 3.) In some of the clumps higher up, however, a further

stage in the succession is the arrival of *Acacia ataxacantha*, which straggles over the whole clump, killing out many of the earlier arrivals, and forming a dense, almost impenetrable thicket.

VII. The Mature Clumps—Detailed Analysis.

The fully formed clumps all closely resemble one another, though showing slight variations in their composition. In the centre of each there is usually a large *Cussonia spicata*, at the base of which is a termites' nest. It would be interesting to know whether this nest is formed before or after the arrival of the Cussonia. In his account of the thorn veld (4) Professor Bews states that "seeds of all the species are apt to be distributed and to germinate on or around white ants' nests." In the one case already mentioned of the earliest observed stage of the succession there was no termites' nest present, but the young Cussonia was growing on an ordinary ants' nest. An isolated case like this, however, does not afford sufficient evidence on which to base any definite conclusions. The Cussonia in the centre of the clump is frequently dead, and in many cases only the stump is left, the tree itself having fallen. The cause of the death of this tree is believed to be the attack of white ants, but this subject is reserved for discussion in a later section of the paper.

Surrounding the central tree is a ring of younger trees, the commonest of these being *Combretum kraussii* and *Clerodendron glabrum*. A bare space is usually left in the centre of the clump round about the Cussonia. Between the trees forming the outer ring there is usually a plentiful growth of *Plectronia spinosa* and other Rubiaceae. Scrambling over the trees are various climbers such as *Rubus pinnatus*, *Smodingium argutum*, *Rhoicissus cirrhiflora*, *Helinus avatus*, *Mikania scandens* (?), and *Asparagus* sp. Numerous herbs occur round the edges of the clumps, *e.g.*, *Teucrium africanum*, *Lantana camara*, and various Acanthaceae. Many others probably occur, but do not flower until later in the year, and consequently were not noted.

The following detailed notes on several typical clumps will illustrate the variations which occur. Since the climbers, shrubs and herbs are practically identical in each case they have been omitted from these notes. The position of the clumps analysed is indicated on the accompanying map (p. 235).

Clump 1.—A large *Cussonia spicata* in the centre. The bark has been almost completely stripped off the lower portion of the trunk. A branch from near the base has fallen and the broken end is covered with earth, indicating the presence of white ants. These appear to be attacking the exposed portions of the roots also. Surrounding the central Cussonia are the following:—*Schmidelia erosa*, *Combretum kraussii* (several trees), *Clerodendron glabrum* (several trees), *Clausena inaequalis*, *Rhus* sp., *Cussonia spicata* (dead and fallen tree).

Clump 2.—A smaller clump than No. 1. The oldest tree is quite obviously a large *Cussonia spicata*. A large branch has recently fallen, and in doing so has broken a young, but

well-grown, *Fagara capensis*. In this case there is little doubt but that the branch was killed by white ants, as these had eaten out a considerable portion of the wood of the branch. A smaller branch has also been attacked, but has not yet fallen and still bears a few leaves. The remainder of the clump consists principally of *Clerodendron glabrum*. Other trees present are:—*Fagara capensis*, *Zizyphus mucronata*, *Ehretia hottentotica*. (See Plate II, Fig. 2.)

Clump 3.—A very small clump, one of the youngest on the hillside. A young *Cussonia spicata* in the centre, still quite healthy, and bark not yet stripped off lower portion of trunk. Surrounding this are:—*Ehretia hottentotica* (principally), *Clerodendron glabrum*, *Zizyphus mucronata*.

Clump 4.—A very open clump on somewhat broken ground. A very old and large *Cussonia spicata*, still quite healthy looking; a second quite dead, but not yet fallen (death in this case could not possibly have been due to shading); a third dead and fallen. Other trees present are:—*Ehretia hottentotica*, *Clerodendron glabrum*, *Gymnosporia buxifolia*. (See Plate III, Fig. 4.)

Clump 5.—A small clump. The oldest tree a large *Combretum kraussii*. Other trees are:—*Clerodendron glabrum* (two or three trees), *Fagara capensis*, *Royena pallens*.

Clump 6.—A large clump composed principally of Acacia *ataxacantha*. A large *Cussonia spicata* has fallen and is completely overgrown by the Acacia. Another Cussonia has probably been killed by white ants. Other trees present are:—*Combretum kraussii*, *Clerodendron glabrum*, *Zizyphus mucronata*.

VIII. The Death of the Pioneer.

One of the most striking features of the foregoing notes is the frequent mention of dead or injured trees of *Cussonia spicata*. In three of the six clumps described there is a dead Cussonia, and in another this tree has recently lost a large branch; with regard to the other two clumps one is still quite young, the other does not contain a Cussonia at all. Indeed no one visiting the hillside can fail to notice the number of dead Cussonias; it is difficult to find a clump in which one at least does not occur. At first the writer was inclined to regard this as simply a further stage of the ordinary succession within the clump, since it frequently happens that a pioneer is killed out by subsequent arrivals. These, unable at first to survive exposure to the full sunlight of the open veld, grow successfully in the shade of the pioneer. Once established, they grow more rapidly than the latter, and eventually overtop it. The pioneer, always an intense light demander, cannot tolerate the shade, and is consequently killed out. The succession in the thorn veld illustrates this very clearly. To quote Professor Bews (4):—

"Very soon the species which began under the thorn tree grow up through it. At a fairly early stage it is common to find *Celastrus* or *Ehretia* towering above it. The lianes such as *Vitis* spp. *Asparagus* spp. sometimes spread all over the top of it. and the thorn tree may ultimately be killed."

The death of *Cussonia spicata* in the clumps described in this paper cannot, however, be ascribed to shading by the overgrowth of surrounding trees and climbers. Normally it grows to a considerable height, and in the majority of the clumps it is quite as high as, if not higher than, the other trees. Again, dead trees frequently occur in situations where it is impossible to ascribe death to shading. Two, at least, occur right out in the open veld, and dead branches are found on trees in clumps where the Cussonia still towers above the younger trees, *e.g.*, Clump 2 in the above notes.

The writer is now quite convinced that the death of this tree is caused by the attack of white ants. In nearly every clump a termites' nest is found at the foot of the Cussonia. The earth tunnels of the termites can often be seen passing up the bark of living trees, and if the bark be removed from dead branches they are found beneath it and often extend right into the wood itself. Living trees are sometimes found with large portions of the trunk completely eaten away by the white ants. Another noticeable feature of *Cussonia spicata* in these clumps is that most of the trees except the younger ones have almost completely lost the bark from the lower portion of the trunk. This seems to be one of the first results of the attack of the white ants, whose tunnels, as we have seen, are frequently found below the bark. There is no indication in any of the clumps examined of the white ants extending their operations to other trees, none of which are stripped of their bark as is the Cussonia, though why this should be so the writer is at present unable to explain.

IX. Summary and Conclusions.

Examples of the more important types of Tree Veld in South Africa are given, and the possibility of further subdivision is indicated. Attention is drawn to a unique feature in the establishment of Tree Veld—the invasion of grassland by trees—and the consequent importance of a study of the succession in each type is emphasised.

A detailed account is then given of a type of Tree Veld, termed a Cussonia-Combretum association, occurring on a hill near Pietermaritzburg. The topography and climate of the hillside is described, and the distribution of Tree Veld in the immediate neighbourhood indicated.

The dominant grass on the hillside is *Aristida junciformis;* a list of others which occur is given.

The main bases of colonisation are a shallow "central valley" and another valley further east. The trees occurring in these are enumerated.

Migration from these valleys has taken place principally towards the east, probably because the eastern sides of the valleys are moister than the western. Definite lines of migration from the "central valley" have been formed along tributary depressions. A map showing the distribution of the clumps on the slopes adjacent to the "central valley" has been prepared.

FIG. 1.

FIG. 2.

MIDLAND TREE VELD, NATAL.

Cussonia spicata is the chief pioneer in the invasion of the grassland, though its place is occasionally taken by *Combretum kraussii* or *Clerodendron glabrum*. A detailed analysis of several clumps is given to show the principal variations in their composition.

Comment is made on the large number of dead Cussonias on the hillside, and evidence is adduced to show that death is due to the attack of white ants.

In conclusion I must acknowledge the encouragement and assistance which I have received from Professor Bews, who has taken a keen interest in the present investigation. I must also express my thanks to Dr. T. R. Sim for assistance in the determination of many species, and to Mr. R. U. Sayce for help in the preparation of the accompanying map.

References.

(1) Bews, J. W.: "The Vegetation of Natal." *Ann. Natal Mus.*, vol. ii (1912), p. 253.

(2) — "An Ecological Survey of the Midlands of Natal," etc. *Ann. Natal Mus.*, vol. ii (1913), p. 485.

(3) — "An Account of the Chief Types of Vegetation in South Africa, with Notes on the Plant Succession." *Journ. Ecology*, vol. iv (1916), p. 129.

(4) — "The Plant Succession in the Thorn Veld." *S.A. Journ. of Science*, xiv (1917), p 153.

(5) — "The Plant Ecology of the Drakensberg Range." *Ann. Natal Mus.*, vol. iii (1917), p. 511.

(6) — "The Plant Ecology of the Coast Belt of Natal." *Ann. Natal Mus.*, vol. iv (1920), p. 367.

(7) Aitken, R. D., and Gale, G. W.: "Botanical Survey of Natal and Zululand. A Reconnaissance Trip through North-eastern Zululand." *Botanical Survey of South Africa*, Memoir 2 (in the press).

Explanation of Plates II and III.

Plate II, Fig. 1: Signal Hill. The "central valley" is on the right and scattered clumps are to the east of this.

Fig. 2: Clump 2. For description see text.

Plate III, Fig. 3: A fully formed clump. Note the open space in the centre.

Fig. 4: For description see text. Note the dead Cussonia in the foreground.

PROTONEMAL DEVELOPMENTS OF MOSSES.

BY

H. WAGER, A.R.C.S.,

Professor of Botany, Transvaal University College, Pretoria.

With 2 Text Figures.

Read July 15, 1921.

A new moss from Port St. Johns has just been named by Mr. Dixon as *Nanobryum Dummeri* gen. and sp. nov. An interesting feature of this moss, although not necessarily specific, lies in its protonema. Instead of being entirely filamentous it shows an advance in the direction of a flat prothallial structure, that is, some cells by lateral division form small flat cellular portions (Fig. 1). The cells so formed apparently retain more especially the power of filamentous division so that irregular and peculiar shapes are sometimes produced. Also, no specialised growing points are found. Buds are produced on the sides of these formations as well as on the filamentous portions. This growth takes place from any part of the protonema and quite often from exposed parts of rhizoids.

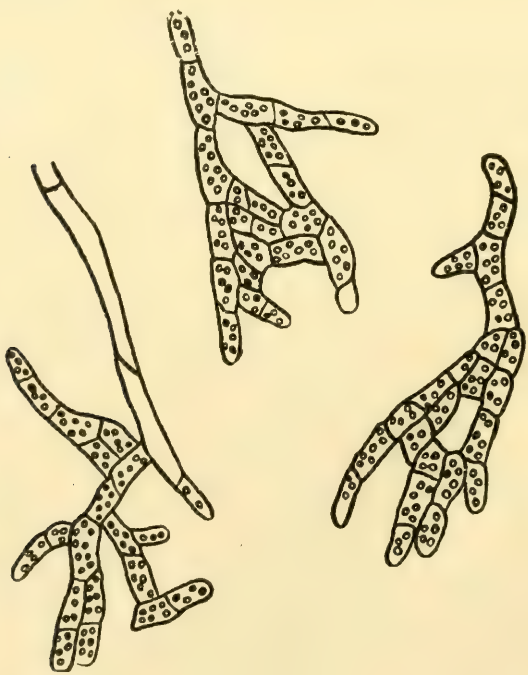


FIG. 1.

Another moss, a species of *Bryum*, on the other hand, which I have had under observation for some considerable time, shows very different protonemal features. The piece of ground on which it grows is shady, but dries up rather quickly. Up to the present it has apparently never been damp long enough to allow of the proper growth of the moss plants, although tiny plants can be seen sparsely scattered over the ground. The fruiting stage has certainly never been reached in the last three years. The ground, however, always becomes green after rain. The green is due to an enormous number of small rod-like filaments, each one having usually four cells. The number of cells is, however, variable, but usually never more than ten, and then small branches are often present. This branching stage is the beginning of a tufted condition. One cell develops many branches, each of which has about four cells. These pieces now become easily detached, thus causing dissemination of the protonema. Moss buds may arise from any cells of these short filaments (Fig. 2). Gametophyte proliferations

FIG. 2.

are fairly common amongst mosses, notably in many species which give rise to filamentous proliferations from the leaves, several species which give rise to gemmae from the moss plants themselves, the formation of bulbils, and the power the rhizoids possess of changing into protonema. A portion of the ground has lately been kept under more suitable conditions of moisture, and so far the results appear to show that the rod-like filaments become more protonema-like in character with the production of many more buds. It would thus appear that the method here described is a response to xerophytic conditions, by means of which the plant extends its existence until more permanent conditions of growth arise.

A CONTRIBUTION TO OUR KNOWLEDGE OF THE POLYPOREAE OF SOUTH AFRICA.

BY

PAUL A. VAN DER BIJL, M.A., D.Sc., F.L.S.,
Professor of Mycology, University of Stellenbosch.

Read July 17, 1920.

CONTENTS.

INTRODUCTION.

For some time the writer has been giving special attention to the *Polyporeae* or Pore-fungi occurring in the Union of South Africa. This group of fungi is of especial economic importance to foresters since a number of them are known to cause serious timber rots. Unfortunately the earlier collections by Wahlenberg, Baur, Tyson, Wood, Macowan and others are not preserved in any institution in South Africa. Some of them have probably been entirely lost, whereas others are preserved in foreign institutions. The Polyporeae are generally recognised as the most difficult of the fungi to name and identify satisfactorily, and even with descriptions the comparison with type specimens is essential. There being at the time no comprehensive collection of correctly named specimens in any of the South African institutions, the writer soon realised the necessity of co-operation with someone who has had an opportunity of studying these fungi from collections preserved in other countries. In this he was fortunate in obtaining the co-operation of Mr. C. G. Lloyd, and it is mainly through his kind and willing assistance in identifying specimens that the work was made possible. I am also much indebted to Mr. C. G. Lloyd for criticisms contained both in his mycological publications and in personal letters to me.

The descriptions of these fungi are very scattered, and to many quite inaccessible; hence it appeared desirable to issue them in a form which would make their study and identification more accessible to South African students.

To the gentlemen who have favoured me with specimens and whose names are appended in the text I am most grateful, and especially to Mr. J. D. Keet, whose large and excellently preserved collections of these fungi from the Eastern Cape Forest Conservancy have been the foundation for this study.

Unfortunately we cannot claim that all the South African Polypores have as yet been collected, but rather than delay publication the writer considered that a better purpose would be served by publishing on the species known to him at present and at a later date to issue an addendum.

Specimens of the fungi herein recorded and not represented in the Herbarium of the Division of Botany of the Department of Agriculture, Pretoria, have been deposited there, and this institution is thanked for the loan of books and access to a few specimens not in my collection.

General Account.

The members of the family *Polyporaceae* are easily recognised by the fact that they have their spores borne on the interior surfaces of tubes or pores (hence the name). In a comprehensive sense this family embraces the subfamilies *Boleteae*, *Merulieae* and *Polyporeae*. Without entering into details we can briefly separate these subfamilies as follows:—

1. Hymenophore (i.e., pore layer) separable from the context or flesh of the fructification. *Boleteae*.
1. Hymenophore not separable as above.
    2. Pores reduced to shallow pits separated by narrow ridges or reticulations. *Merulieae*.
    2. Pores well developed and varying in size and form. *Polyporeae*.

We are here concerned only with the latter sub-family.

The sporophores, as the fructifications of the Polyporeae are called, are well-known objects to most people, forming, as many of them do, the familiar "brackets" or "shelves" on living trees or old stumps. Though the majority occur on wood, a few (e.g., *Polyporus nigro-lucidus*) are terrestrial.

Form of the sporophores. The fruiting body of the pore-fungi either show a distinct cap or shelf when they are said to be pileate or are more or less spread out flat on the substratum and are said to be resupinate. Pileate forms may either be sessile or elevated by a stipe. In some species the form is fixed and little variation is seen, whereas in others it varies.

Thus *Polyporus lucidus* may be either sessile or stipitate and many pileate species (such as *P. gilvus*) show sub-resupinate or even entirely resupinate forms. In stipitate forms the stipe may

be either central, excentric or lateral, and this, too, is a character fixed in some and variable in others. In a very few species the stipe arises from a tuber or sclerotium.

The sporophores are either annual or perennial. In some of the annual species the sporophores may survive a second season (e.g., *P. gilvus; P. fruticum*).

In consistency the sporophores of the different species show considerable variation. They vary from spongy forms like *P. fruticum*, through soft fleshy forms such as *P. sulphureus*, to fibrous and flexible forms like *P. versicolor*, and extremely hard and woody forms such as the majority of *Fomes* spp.

In shape, considerable variation is found. Some are circular, others semi-circular, fan-shaped, hoof-shaped or flat, funnel-shaped, ear-shaped, etc. In distinguishing the different shapes various terms are used such as ungulate (hoof-shaped), dimidiate (semi-circular), infundibuliform (funnel-shaped).

Surface of the sporophores. The sporophores show striking differences in surface modifications. Thus, we find species like *Fomes applanatus* and others with a hard, horny, encrusted surface, and in some of these the crust has the appearance of being covered with varnish (e.g., *P. lucidus*, *P. nigro-lucidus*, and others). In others the surface hyphae end loosely and form hairs of various types and descriptions. The surface may be smooth, furrowed, zoned, wrinkled, dotted with tubercles, and in some, rough, with appressed fibrils.

The sporophore can for our purpose be considered as composed of two main regions (a) the layer or layers of tubes termed the hymenophore and (b) the region above this pore layer known as the flesh or context of the sporophore.

The Context or flesh. The colour of the context varies for different species, and this character is used for separating the species. In consistency the context also varies considerably, but is fairly constant for each species. In many the context is hard and woody (e.g., majority of species of *Fomes*); in others, again, it may be corky, cheesy, fleshy, tough or fibrous. In a few it is spongy (e.g., *P. fructicum*) and in some it is floccose (e.g., *P. colossus* and others). In some the context becomes very fragile when the fungus is dry (e.g., *P. immaculatus*).

The Hymenophore. The term hymenophore is used to denote that part of the fructification on which the spore-bearing region or hymenium arises. Used in this sense it would include the interior tissue of the pores and the tissue at the base of the tubes. Since the poroid character of the hymenophore separates the *Polyporeae* from related families and subfamilies, it is taxonomically an important region, the nature of the pores or tubes also being used in distinguishing different genera of the sub-family. Thus the genus *Hexagona* has subrotund or hexagonal and usually large pores; the genus *Favolus* large, angular pores which are elongated radially; the genus *Daedalia* typically labyrinthiform pores. In the genus *Lenzites* the pores become changed so that their poroid character is not always readily discernable. The

hymenophore is here lamellate and thus connects the *Polyporaceae* with the *Agaricaceae*. Some of the *Lenzites* spp., however, show the poroid character at least in the early stages. The edges of the pore-mouths are either thick or thin and may be entire, lacerate, or toothed (*P. biformis*, *Trametes albotexta*). Extremely toothed species, such as *Polyporus flavus*, Jungh connect the *Polyporaceae* with the *Hydnaceae*.

The hymenium. The lining inside the tubes on which the spores are borne is known as the hymenium or hymenial layer. Essentially this layer is composed of the spore mother cells or basidia from which the spores (basidiospores) are abstricted. Modified outgrowths from the pore tissue cells, which grow into the hymenial layer, occur between the basidia in many species. These outgrowths are of two kinds (1) colourless and either pointed or inflated outgrowths known as cystidia (as in *Lenzites betulina*); (2) coloured outgrowths of the nature of spines. These latter are known as setae. Setae are of common occurrence in some species, and this character is used for separating the species. In the majority the setae are simple and sharp-pointed, rarely are they bifid. In *Favolus megaloporus* the setae are themselves again beset with spine-like outgrowths.

These setae are generally found in the hymenium, although they sometimes occur buried in the tissue of the pore-walls (e.g., *P. patouillardii*, *P. ochroporus*) and even in the context tissue (*F. pachyphloeus*).

The spores. The spores show the usual variations found in a large group of fungi. In shape they vary from round to oblong or elliptical, and may be either smooth or rough with minute projections. They are colourless, lightly coloured, yellowish, or some shade of brown. It is unfortunate that so frequently in collections of these fungi the spores are not found. Species with white or light coloured context have hyaline spores, whereas in those with dark coloured context the spores are either hyaline or coloured. When coloured they are usually present in the specimens. One type of spore found in a limited number of species herein described —namely, the so-called truncate spore—requires mention. In these the spores have a hyaline membrane which projects beyond the base and forms an apiculum. The empty apiculum collapses, and the spores at this end then have the appearance of being abruptly cut off and are said to be truncate. *P. ochroleucus* and *Fomes ohiensis* have hyaline truncate spores, whereas *Fomes applanatus*, *Polyporus lucidus*, *P. nigro-lucidus*, and others have coloured truncate spores.

The Genera Herein Dealt With.

We have included in this paper the following genera:— *Polyporus* (including *Polystictus*), *Fomes*, *Trametes*, *Hexagona*, *Favolus*, *Laschia*, *Lenzites*, *Daedalia*.

The genus *Hexagona* with its usually large, subrotund or hexagonal pores connects through the small pored *Hexagona tenuis* with the genus *Polyporus*. The *Fomes* include the perennial

species with the pore layers in successive strata. *Trametes* include annual and perennial forms. It is distinguished from *Polyporus* and *Fomes* by its usually pinky context and by having the pores not in a definite layer but sunk to different depths in the context tissue. The genus *Favolus* includes laterally stalked forms with large angular pores radially elongated. *Laschia* spp. are small, gelatinous, sessile, or stipitate polypores. In *Lenzites*, as mentioned, the pores are replaced by plates, but, through forms which first show a poroid character, this grades into the more typical pore fungi and they are classed here rather than with the Agarics or "Gill-fungi." In *Daedalia* the hymenial surface is labyrinthiform and forms connect this genus with *Polyporus* and *Trametes* on the one side and with *Lenzites* on the other.

We include the genus *Polystictus* in *Polyporus*. No distinct line can be drawn between these genera and in working over a restricted area it is considered best to fuse them. The names *Polyporus* and *Polystictus* have been applied almost interchangeably to the thin leathery polypores which are often separated under the latter name.

Very little is known about the South African resupinate forms included in the genus *Poria*, and this genus is for the present omitted.

Economic Importance of the Group.

From the utility point of view the object in preserving and demarcating large tracts of forest areas is for the wood or timber such areas can be expected to produce. Anything, therefore, which may tend to reduce the annual rate of wood production or destroy the wood already formed should receive careful attention.

The "pore-fungi" are amongst the most serious of the fungi responsible for rots in trees and timber. Some, for example, *Fomes rimosus*, attack only the heartwood and cause what is popularly called "heart-rot." Others, such as *Fomes applanatus*, *Polyporus lucidus*, attack the sap-wood causing "sap-rot." According to the nature of the parasitism we can distinguish forms which only live on living trees and whose growth cease with the death of the host, for example, *Fomes rimosus* and those which usually grow on dead logs and wood, but may at times become parasitic, for example, *Fomes applanatus*, *Polyporus lucidus*, *Polyporus sulphureus*, *Trametes obstinatus*, *Polyporus sanguineus*, *Polyporus versicolor*, and others. Those responsible for the decay of trees all gain entrance through wounds.

It is hoped that this paper may assist foresters in identifying the fungus forms they meet in their different areas, and may in a small measure contribute towards a better knowledge and understanding of those responsible for the decay of our South African timber trees.

Key to the Genera.

1. Sporophores entirely resupinate and never developing pileate forms. *Poria* (vide general account).

1. Sporophores typically pileate, though several are also more or less resupinate at times.
2. Hymenophore gelatinous and separable from context as an elastic membrane when moist. (Vide *P. conchoides*, p. 258 and *P. dichrous*, p. 257.)
Glœoporus. Here included in *Polyporus*.
2. Hymenophore not gelatinous and not separable from context in a distinct layer as above.
3. Sporophores small, more or less gelatinous throughout, laterally stipitate, epixylous. *Laschia*, p. 292.
3. Sporophores leathery, corky or woody, never gelatinous.
4. Hymenophore poroid, in some tending to labyrinthiform or daedaloid.
5. Pores medium size, round or angular, and if angular, irregular.
8. Tubes forming a well marked stratum all sunk to equal depths in the context.
6. Pileus annual, with a single porelayer, sessile or stipitate, epixylous or terrestrial. *Polyporus*, p. 251.
6. Pileus perennial, producing a new layer of tubes each season, sessile, epixylous. *Fomes*, p. 272.
8. Tubes not forming a well-marked stratum, sunk to different depths in context; pileus epixylous, sessile, annual or perennial. *Trametes*, p. 279.
5. Pores large, angular.
7. Pileus epixylous, laterally stipitate, pores angular, radially elongated. *Favolus*, p. 291.
7. Pileus epixylous, sessile, pores large, round to hexagonal (the small-pored *Hex. tenuis* and its allies are distinguished from Polyporus by the pores being angular and regular. *Hexagona*, p. 289.
4. Hymenophore typically labyrinthiform (daedaloid) in part at least, in some poroid at first; pileus sessile, epixylous. *Daedalia*, p. 286.
4. Hymenophore typically lamellate, in part at least(in *L. trabea* usually poroid) pileus epixylous, sessile (in *L. repanda* substipitate). *Lenzites*, p. 287.

Keys to and Descriptions of the Species.

Polyporus (Mich) Fries.

Plants annual or sometimes persisting a few seasons, epixylous or terrestrial; pileus sessile or stipitate, small or of large size, some brightly coloured, a few possessing a laccate surface; context white, red, yellow or brown; tubes in a single layer and sunk into context tissue to equal depths so that their bases form a continuous straight line; mouths circular or angular, varying in size, rarely showing a daedaloid or favoloid tendency; spores hyaline or coloured, in a few truncate; setae absent or present, usually confined to hymenium and very rarely occurring in the pore-walls or context tissue; stipe when present varying from central to excentric or lateral, in *P. sacer* it arises from a sclerotium and in *P. arenosobasus* from a false sclerotium.

The basic idea of the genus *Polyporus* is that its members have only a single layer of pores (distinguish from *Fomes*) which are sunk in the context to equal depths (distinguish from *Trametes*). *Fomes* spp. showing only the first year's pores may be mistaken for a *Polyporus*. Some of the species of *Polyporus* (e.g., *P. gilvus*, *P. fructicum*) may survive a few seasons, but they are never typically perennial. Some species grade into *Trametes*, and it may not always be easy to decide whether a specimen is a *Polyporus* or a *Trametes* (cf. *P. occidentalis*, *Tr. protea*, and others). In *P. arcularius* we find large favoloid pores suggesting the genus *Favolus*, from which however it differs in having its stipe central. In *P. occidentalis* and others a daedaloid tendency of the hymenophore may be at times met with.

KEY TO THE SPECIES.

Context white or light coloured.	Series I.
Context red or yellow.	Series II.
Context some shade of brown, an elastic membrane.	Series III.

Series I.

Context white or light coloured.

1. Pileus stipitate.
2. Stipe arising from a true or "false" sclerotium.
3. A true sclerotium present. *P. sacer* 1
3. Sclerotium "false" composed of agglutinated soil particles. *P. arenosobasus* 32
2. Stipe not arising from a sclerotium.
4. Stipe lateral.
5. Spores truncate, coloured.
6. Plant epixylous, surface laccate, reddish brown. *P. lucidus* 37
6. Plant terrestrial, deeply rooted, surface laccate and black in mature specimens. *P. nigrolucidus* 35
5. Spores hyaline, not truncate.
7. Surface of pileus black. *P. dictyopus* 2
7. Surface of pileus brown, azonate. *P. varius* 3
7. Surface of pileus yellow, or brown, zoned, pores minute. *P. luteus* 24
7. Surface of pileus yellow, orange or white; plants densely imbricate, large, fleshy; context of a cheesy consistency and friable when dry. *P. sulphureus* 33
4. Stipe central or more or less excentric.
8. Spores hyaline, not truncate.
9. Pores large, radially elongated, stipe central, margin of pileus ciliate. *P. arcularis* 4
9. Pores minute, round, stipe central or excentric, surface of pileus with multicoloured zones. *P. xanthopus* 5
8. Spores coloured, truncate.

10. Plants terrestrial, deeply rooted, surface laccate, black in mature plant. *P. nigrolucidus* 35
10. Plants epixylous, surface redbrown, laccate. *P. lucidus* 37

1. Pileus sessile.

11. Hymenophore when moist separable from context as an elastic membrane.
12. Mouths reddish-purple. *P. dichrous* 6
12. Mouths white or flesh coloured. *P. conchoides* 7
11. Hymenophore not separable from context as above.
13. Spores truncate.
14. Spores hyaline. *P. ochroleucus* 8
14. Spores coloured. *P. lucidus* 37
13. Spores not truncate, hyaline.
15. Edges of pore mouths soon breaking up into teeth. *P. biformis* 9
15. Edges of pore mouths not breaking up into teeth as in preceding.
16. Plants largely resupinate and with small reflexed pilei.
17. Pileus white, changing to reddish, mouths 6 or 7 to the millimetre. *P. undatus* 10
17. Pileus not changing as above, soft and spongy, largely resupinate, mouths large, 1 to 3 to the mm., shallow, irregular; spores large. *P. versiporus* 11
17. Pileus not changing, coriaceous, mouths 2 to 3 to the mm. *P. pinsitus* 19
16. Pileate portion usually more or less well developed.
18. Surface with multicoloured zones.
19. Context 1 mm. or less thick.
20. Surface velvety, tubes exceeding 1 mm. in length. *P. versicolor* 12
20. Surface more strigose, less conspicuously zoned, tubes not exceeding 1 mm. in length. *P. hirsutulus* 13
19. Context more than 1 mm. thick *P. zonatus* 14
18. Surface sometimes zoned, but not marked with multicoloured zones.
21. Surface with a conspicuous hairy covering.
22. Context exceeding 1 mm. in thickness.
23. Tubes less than 1 mm. long. *P. velutinus* 15
23. Tubes more than 1 mm. long.
24. Surface hirsute, pore mouths entire, persistently thick-walled, 3 to 4 to mm. *P. hirsutus* 16
24. Surface hirtose-villose, pore mouths becoming thin walled, often dentate, 2 to 3 to mm. *P. pubescens* 17
22. Context 1 mm. or less in thickness.
25. Tubes more than 1 mm. long.
26. Surface with a soft cottony pubescence, pore mouths 2 to 3 to the mm. *P. hirtellus* 18
25. Tubes less than 1 mm. long.
27. Pileus thin, flexible, mouths irregular angular, shallow, 2 to 3 to mm. *P. pinsitus* 19

27. Pileus more firm and rigid, surface hirtose to villose tomentose or subglabrous, mouths 4 to 6 to mm. *P. velutinus* 15
21. Surface minutely tomentose to glabrous.
28. Entire plant grey, surface finely tomentose, pruinose, pore mouths 4 to 5 to mm. *P. durbanensis* 20
28. Plants not grey.
29. Context friable in dry plants.
30. Plants growing densely imbricate and forming large masses; pileus fleshy when fresh, yellow to orange or white, context of a cheesy consistency and friable when dry, tubes develop easily on any part of pileus. *P. sulphureus* 33
30. Plants not growing densely imbricate; pileus fleshy when fresh, white; context fragile and crumbly when dry; tubes not forming readily as above. *P. immaculatus* 22
29. Context not friable as above.
31. Plants growing densely imbricate; pileus thin (less than 1 cm.), surface finely tomentose, creamy white to yellow; pore mouths 5 to 6 to mm. *P. trichiliae* 21
31. Plants rarely imbricate; pileus large, exceeding 1 cm. in thickness; surface white to discoloured; spores large, globose. *P. robiniophila* 23

Series II.

Context yellow or red.

1. Pileus sessile.
2. Pileus and hymenium deep cinnabar red.
3. Pileus less than 5 mm. thick. *P. sanguineus.* 25
3. Pileus more than 5 mm. thick. *P. cinnabarinus* 26
2. Pileus and hymenium not deep cinnabar red.
4. Surface densely tomentose or hispid. *P. occidentalis* 27
4. Surface covered with a thick pad of coarse, branched fibrils. *P. leoninus* 28
4. Surface of pileus not as above.
5. Context cheesy and friable, crumbly when dry; pileus fleshy. *P. sulphureus* 33
5. Context floccose, soft-spongy.
6. Pileus circular, tubes as much as 3 mm. long. *P. mollicarnosus* 29
6. Pileus pulvinate; tubes not exceeding 1 cm. in length. *P. colossus* 30
5. Context not as above.
7. Plants largely resupinate; pileus small, buff coloured; context pinkish buff; spores hyaline ellipsoid. *P. conchatus* 31
7. Pilei well developed; context yellow or yellow brown; spores hyaline, globose. *P. anebus* 34

1. Pileus stipitate or sub-stipitate.
   8. Stipe central, arising from a false sclerotium composed of agglutinated soil particles. *P. arenosobasus* 32
   8. Stipe not arising from a sclerotium.
   9. Pileus and hymenium deep cinnabar red. *P. sanguineus* 25
   9. Pileus and hymenium not as above; yellow or orange; plants densely imbricate; fleshy; context soft, of a cheesy consistency and friable when dry. *P. sulphureus* 33
   9. Context floccose. *P. colossus* 30

Series III.

Context some shade of brown.

1. Pileus stipitate.
   Surface laccate; spores coloured, truncate.
   2. Surface of pileus and stipe black, laccate. *P. nigro-lucidus* 35
   2. Surface of pileus and stipe a red or chestnut, laccate.
   3. Mouths reddish-purple. *P. mastoporus* 36
   3. Mouths white or yellowish. *P. lucidus* 37

1. Pileus sessile.
   4. Surface laccate, spores coloured, truncate.
   5. Mouths reddish-purple. *P. mastoporus* 36
   5. Mouths white or yellowish. *P. lucidus* 37
   4. Surface not laccate; spores not truncate, hyaline or coloured; setae absent or present.
   6. Context wholly or in part brittle; setae in walls of tubes.
   7. Context of same consistency throughout and brittle; spores coloured; setae present. *P. patouillardii* 39
   7. Context soft above, hard and brittle below; spores coloured, setae present. *P. ochroporus* 40
   6. Context not brittle.
   8. Setae present.
   9. Surface with a dense velvety pad of reddish brown hairs. *P. tabacinus* 38
   9. Surface not with such a pad, minutely pubescent, smooth to very rough. *P. gilvus* 41
   8. Setae absent.
   10. Pileus spongy; context duplex, upper region soft and contrasting with firm tubes; plants most frequently encircling twigs. *P. fruticum* 42
   10. Pileus not as above.
   11. Context purple and whole plant concolorous. *P. vinosus* 43
   11. Context olive brown.
   12. Surface glabrous, fawn coloured to olive. *P. aratus* 44
   12. Surface variously pubescent. Vide *Trametes protea*

11. Context yellowish brown or brown but not olive or purple.
13. Surface of pileus distinctly pubescent.
14. Pileus 1 mm. or less thick; surface velvety tomentose, umber-brown, zoned. *P. phocinus* 45
14. Surface azonate, with a reddish brown velvety to villous or hirsuty pubescence. *P. flexilis* 46
13 Surface of pileus glabrous or minutely pubescent.
15. Pileus thin, flexible, surface with raised concentric zones; margin thin, crenate. *P. subpictilis* 47
15. Pileus firm, surface not with raised concentric zones as above.
16. Spores hyaline, globose, 3·7μ diameter. *P. anebus* 34
16. Spores hyaline, elliptical, 5μ to 7μ by 3μ to 4μ. *P. subradiatus* 48
13. Surface of pileus very rugulose and scrupose. *P. rusticus* 49

1. *Polyporus sacer*, Fries.

Pileus orbicular 7·5 cm. to 10 cm. diam. borne on a stalk centrally attached, 4 cm. to 10 cm. high by 7 mm. to 12 mm. diam., which arises from a sclerotium 6·5 cm. by 3·5 cm.; surface of pileus zoned, horny-encrusted, hard, rugulose, furrowed, greyish to dark-brown, velutinate to glabrous; context 0·75 mm. to 1·5 mm., soft, fibrous to membranous, white to yellowish; tubes 2·5 mm. long, white, changing yellowish; mouths angular, 2 to the mm., edges firm, entire white to yellowish; spores hyaline 9μ to 13μ by 6·5μ to 7·5μ; hyphae 4μ to 5·5μ.

Distribution.—W. Thorncroft at Barberton, Transvaal; J. M. Wood at Durban, Natal; Col. Friend Addison at New Guelderland, Natal.

Recognised by the stalked, velutinate and zoned pileus arising from a sclerotium.

2. *Polyporus dictyopus*, Mont.

Pileus stipitate, thin, coriaceous, orbiculate to flabelliform, depressed, 3 cm. to 4 cm. diam. by 1 mm. thick; surface black, glabrous, zonate, radially striate; margin thin, undulate to lobed; context white to yellowish, 0·3 mm. thick; tubes 0·7 mm. long, white when fresh, changing to brownish, decurrent on stipe; mouths angular 4 to 6 to the mm., edges thin becoming lacerate, white changing to brownish; stipe excentric, black, glabrous, about 7 mm. long by 5 mm. diam., spores (teste Bresadola) hyaline, oblong, 7μ to 8μ by 3μ to 3·5μ; hyphae 2μ to 4μ.

Distribution.—From collection in Natal, by J. M. Wood.

3. *Polyporus varius*, Fries.

Pileus stalked, varying in form from sub-orbicular to reniform, flabelliform or spathulate, often lobed; tough and leathery when fresh, firm, hard and woody when dried, 2·4 cm. to 10·5 cm. by 2 cm. to 8 cm. by 3·7 cm.; surface glabrous, radially striate and

smooth or rough with radial ridges, red-ochre to dark; context white to yellowish 1·5 mm. to 5 mm., corky; tubes 0·5 mm. to 2 mm., white changing to cinnamon, decurrent on stalks; mouths subrotund to angular, 4 to 5 to the mm., edges entire, white at first but changing to cinnamon brown; stalk lateral or excentric 0·4 cm. to 4 cm. by 0·6 cm. to 2 cm., same colour as pileus and glabrous, hyphae 2μ to 3·7μ diam.

Distribution.—Eastern Cape Conservancy on dry *Curtisea faginea*.

In younger specimens the context appears homogenous but in an old specimen I observed it divided into a lower dark brown very hard and horny part and an upper lighter part.

4. *Polyporus arcularius* (Batsch), Fries.

Plants annual, stalked, pileus circular 0·3 cm. to 1 cm. diam. by 1 mm. to 2 mm. thick, umbiliacate, rigid when dry, coriaceous when fresh; surface concentrically rugose when dry, more or less squamulose, brown, margin involute on drying, ciliated; context scanty white, tubes 1 mm. long, decurrent on stipe; mouths white, discoloured in dried specimens, angular, radially elongated, averaging 2 to 3 to mm. in radial direction and 1 to the mm. in axial direction; stalk central 1·5 cm. to 2 cm. long by 0·5 mm. to 1·5 mm. diam., hispid tomentose, brown.

Distribution.—At Durban, Natal, on decaying wood, found by the writer.

The specimens seen by the writer were small and would have been referred to *P. arculariformis*, Murr., which, however, appears to be little more than a small form of *P. arcularius* and not specifically distinct from it.

5. *Polyporus xanthopus*, Fries.

Pileus thin, leathery, orbicular, infundibuliform, 4·5 cm. to 16 cm. diam. and 0·3 mm. to 1 mm. thick, borne on a short glabrous stipe 3 mm. to 5 mm. long, which is usually centrally attached, though at times more or less excentric, expanded at the base into a disc; surface zoned, multicoloured, light ochre, chestnut red, purple brown to dark sepia-brown, glabrous; margin thin, undulate to lobed, sterile; context 0·2 mm. to 0·8 mm. white, fibrous; tubes exceedingly short; mouths circular 7 to the mm.; edges entire, white.

Distribution.—Ngoye Forest, Zululand, on wood, by W. Haygarth and E. Ballenden; A. Roberts at Nelspruit, Transvaal.

In specimens growing close together the pilei of separate plants fuse.

6. *Polyporus dichrous*, Fries.

Pileus sessile or effused reflexed, dimidiate to conchate, imbricate, coriaceous becoming firm and brittle on drying, 1 cm. to 12 cm. by 1·2 cm. to 5 cm. by 0·15 cm. to 0·6 cm.; surface white to yellowish, glabrous to velvety-villous; context white, thin, 1 mm. to 4 mm., soft-fibrous; tubes less than 1 mm. long, fleshy coloured

to reddish-purple, separable from context as a thin elastic layer when moistened; mouths subrotund, 6 to 7 to the mm.; edges entire, reddish purple to blackish; spores (teste Lloyd) hyaline, allantoid, 4μ to 5μ by $1{\cdot}5\mu$; hyphae 4μ.

Distribution.—On dry *Podocarpus sp.* and *Rhus lævigata* in Eastern Cape Conservancy; W. Haygarth, Ngoye forest, Zululand; Nottingham Road, Natal, by the writer.

Recognisable by dark coloured gelatinous tubes separable from the context.

7. *Polyporus conchoides*, Mont.

Pileus thin, sessile, imbricate, laterally connate, coriaceous, 6 cm. to 10 cm. by 5 cm. to 7 cm. by 0·5 cm. to 0·7 cm.; surface glabrous to hirsute, rough, pure white when fresh, becoming yellowish; context thin. 0·5 mm. to 0·6 mm. soft-fibrous; tubes short, 0·5 mm. or less, white, drying flesh colour, gelatinous when fresh or moistened and separable from context as an elastic layer; mouths sub-rotund to angular, 4 to 5 to the mm.; edges thin, entire, white become flesh colour; spores hyaline, allantoid, $4{\cdot}5\mu$ to 5μ by 1μ to $1{\cdot}8\mu$; hyphae $3{\cdot}6\mu$ to 5μ.

Distribution.—W. Haygarth at the Ngoye Forest, Zululand, on logs.

Distinguished from *P. dichrous* by different colour of pores.

8. *Polyporus ochroleucus*, Berk.

Pileus sessile, applanate to ungulate, small, 1·4 cm. to 2 cm. by 0·7 cm. to 1 cm. in a few specimens attached by a reduced base, surface yellowish-ochre, dark coloured in old specimens, rough with appressed fibres, or smooth, indistinctly zoned; context 3 mm., hard, fibrous, pale yellowish; tubes 1 mm. to 4 mm. long, white becoming yellowish; mouths circular 4 to the mm., edges entire, thick, white, spores oblong, hyaline, truncate, 13μ to 15μ by $7{\cdot}4\mu$; hyphae 4μ to 6μ diam.

Distribution.—Found saprophytic on *Trichocladus* sp. and on *Curtisea faginea* in Eastern Cape Forest Conservancy by J. D. Keet and the writer.

The hyaline, truncate, spores combined with the small size and colour of the pileus would serve to recognise this fungus. On the under surface the pileus is often convex.

9. *Polyporus biformis*, Klotz.

Pileus sessile, effused reflexed, coriaceous, soft and pliable when fresh, the reflexed portion dimidiate, applanate, imbricate, laterally confluent, 3·5 cm. to 6 cm. by 1·3 cm. to 3 cm. by 0·6 cm. to 1·3 cm.; surface white to yellowish-buff, rough with appressed fibrils or rarely smooth; context soft corky, fibrous, white to yellowish, 1 mm. to 5 mm. thick; tubes 2 mm. to 5 mm. long, white when fresh becoming discoloured; mouths irregular, circular to angular, 1 to 2 to the mm.; edges thin, soon breaking up into teeth; spores hyaline, oblong, curved, $6{\cdot}4\mu$ to 7μ by $2{\cdot}7\mu$; hyphae 3μ to 4μ diam.

Distribution.—On old logs in Eastern Cape Forest Conservancy, found by J. D. Keet and the writer; also recorded from Natal by J. M. Wood.

The fungus can usually be recognised by its effused reflexed pileus with rough white to tan coloured surface and relatively long tubes the edges of which become lacerate dentate at an early age.

10. *Polyporus undatus*, Pers.

Plants largely resupinate with small reflexed pilei; surface tomentose, velvety, white becoming discoloured to a reddish-brown; context white becoming light yellowish, fibrous corky, hard in dried material; tubes 1 mm. to 2 mm. long, white to yellowish within; mouths small, subrotund to irregularly angular, 6 to 7 to the mm.; edges white to yellowish, thin, often lacerate; spores (according to Lloyd) hyaline, globose, 3μ to 4μ diam.; hyphae 3μ to 4μ diam.

Distribution.—Saprophytic on logs at Pietermaritzburg, Natal, recorded by the writer.

11. *Polyporus versiporus*, Pers.

Plants largely resupinate, widely effused with reflexed soft and spongy pilei 2 mm. or less thick; surface tomentose, velvety, creamy white; context thin, white, soft-fibrous; tubes 0·3 mm. to 2 mm., elongated on decurrent portion; mouths large, unequal, irregularly angular, 1 to 3 to the mm.; edges thin, creamy white, becoming lacerate, spores large, hyaline, guttulate; hyphae 4μ diam.

Distribution.—Found on dead pieces of wood around Durban by the writer. Common.

The pilei are not always developed, and in their absence the plant would be referred to the genus Poria. The plant is recognised by the short tubes with large irregularly angular mouths.

12. *Polyporus versicolor* (Linn), Fries.

Pileus thin, sessile, or effused reflexed, coriaceous, imbricate to single, applanate, dimidiate to orbiculate, often attenuated at point of attachment (spuriously stipitate), 1·5 cm. to 8 cm. by 1·5 cm. by 0·1 cm. to 0·2 cm.; surface smooth, shining, velvety to villous, and marked with conspicuous zones of varying colours, from whitish to yellow, brown or black; context thin, less than 1 mm. thick, fibrous; tubes 0·5 mm. to 2 mm. long, white to yellowish; mouths circular to angular 4 to 5 to the mm.; edges white to yellowish, glistening, edges thin, becoming somewhat lacerate; spores hyaline, smooth, oblong or allantoid, $4{\cdot}6\mu$ to $6{\cdot}34\mu$ by $1{\cdot}2\mu$; hyphae 4μ to 9μ.

Distribution.—Common on dead logs and observed by the writer as a wound parasite on peach trees in the Paarl and Stellenbosch districts, Cape Province. Rarely it is almost entirely resupinate with a small reflexed margin.

Polystictus azureus Fr. is a form of *P. versicolor* with a preponderance of blue.

13. *Polyporus hirsutulus*, Schw.

Pileus thin, sessile, coriaceous, imbricate 3 cm. to 5 cm. by 2 cm. by 0·1 cm. to 0·2 cm.; surface greyish to ashy, zoned with a few coloured zones, hirsute to hispid, context white, thin, tubes less than 1 mm. long, white within; mouths subrotund to angular, 4 to 5 to the mm.; edges thin, entire, white to yellowish, glistening.

Distribution.—Recorded by T. R. Sim at Pietermaritzburg, Natal (in National Herb. Division Botany, Pretoria).

Close to *P. versicolor* from which it differs in being paler and with more hirsute or hispid pubescence and less distinct zones.

14. *Polyporus zonatus*, Fries.

Pileus sessile or effused reflexed, coriaceous, applanate, dimidiate to orbiculate, often attenuated at attachment (spuriously stipitate); 1·5 cm. to 5·5 cm. by 2 cm. to 8 cm. by 0·1 to 0·4 cm.; surface marked with coloured zones as in *P. versicolor*, velvety to sub-villous, context white, azonate, fibrous, 1 mm. to 2 mm. thick; tubes white to yellowish 1·5 mm. to 2 mm.; edges long; mouths circular to angular 2 to 4 to the mm., edges white to yellowish, thin, becoming somewhat lacerate; hyphae 4·6μ to 8μ.

Distribution.—Very common on dead logs throughout the Union.

This fungus is very similar to *P. versicolor*, and only differs from it in thicker context, larger pore-mouths, and surface usually not as villous as the first-named.

15. *Polyporus velutinus*, Fries.

Plants annual, sessile or reduced at attachment; pileus dimidiate, coriaceous-corky to firm, 0·5 cm. to 3 cm. by 0·15 cm. to 4 cm. by ·05 cm. to 0·2 cm.; surface radially zoned to furrowed, villous-hirtose tomentose to finely tomentose and subglabrous, white to yellowish; context 1 mm. to 1·5 mm. thick, white to pallid, fibrous; margin thin and at times incurved in drying; tubes less than 1 mm. long, white to discoloured within; mouths subrotund to angular 3 to 6 to the mm.; edges thin, entire to lacerate, white to umber; hyphae hyaline, 3·6μ to 8μ.

Polyporus velutinus is close to *P. pubescens* from which it differs in being thinner and having shorter tubes.

16. *Polyporus hirsutus* (Wulf), Fries.

Pileus dimidiate, imbricate, sessile, somewhat decurrent at point of attachment or effused reflexed and sub-resupinate, flexible when fresh, leathery and corky in dried material, 2 cm. to 10 cm. by 2·5 cm. by 0·3 cm. to 1·3 cm.; surface conspicuously hirsute, usually concentrically sulcate and zoned, greyish, yellowish or brownish; context white, 2 mm. to 6 mm., fibrous, soft corky; tubes 1 mm. to 3 mm. long, white to yellowish; mouths 3 to 4 to the mm.; circular to somewhat angular; edges thick, entire, white to yellowish; hyphae 0·4μ to 7·4μ diam.

Distribution.—On dead wood, not uncommon. Geo. Thorncroft, Barberton, Transvaal; J. W. Bews, Pietermaritzburg, Natal; W. J. van der Merwe, Eastern Cape Forest Conservancy.

Collections with the pores "trametoid" have also been found. It is distinguished from *P. versicolor* by the hirsute surface and the absence of multicoloured zones. Specimens of *P. ochraceus* (Pers), Fr., and *P. polyzonus*, Fr., are referred here.

17. *Polyporus pubescens* (Schum), Fries.

Plants annual, sessile; pileus applanate, dimidiate, leathery, to corky, more firm when dry, 1·5 cm. to 6 cm. by 0·2 cm. to 4·5 cm. by 0.65 cm. to 0·9 cm., thickest behind, and slightly decurrent; surface zoned, creamy white to greyish brown, villous-hirtose tomentose; context 1 mm. to 6 mm. thick, white to yellowish, zoned, fibrous, tough; tubes 1 mm. to 2 mm. long; mouths subrotund, 2 to 3 to the mm.; edges thick becoming thin and often somewhat lacerate and denticulate; spores hyaline; hyphae 4μ to 8μ.

Distinguished from *P. hirsutus* by less hirsute surface and the pore mouths becoming dentate.

18. *Polyporus hirtellus*, Fries.

Pileus sessile, or slightly decurrent at attachment, coriaceous, laterally connate, 4 cm. to 5 cm. by 4 cm. to 6 cm. by 0·1 cm. to 0·4 cm.; surface at times sulcate, azonate or zoned, covered with a soft cottony pubescence, white to greyish; margin thin, undulate; context white, 0·5 mm to 1 mm. thick; tubes 1 mm. to 2 mm. long; mouths subrotund when young becoming irregularly angular, unequal, 1 to 3 to the mm.; edges thin, entire to denticulate, white changing to yellow or dark brown.

Distribution.—Found by T. R. Sim at Pietermaritzburg, Natal Province (Herb. Div. Bot., 9141); G. Hobbs, at Howick, Natal. The fungus is recognisable by the soft- cottony pubescence.

19. *Polyporus pinsitus*, Fries.

Pileus thin, flexible, largely resupinate, effused-reflexed laterally connate, 2 cm. to 4 cm. by 0·5 cm. to 1·5 cm. by 0·03 cm. to 0·2 cm.; surface indistinctly zoned, white to creamy or ashy, velvety villous; context white to yellowish, 1 mm. or less thick; tubes short, less than 1 mm. long; white changing to yellow; mouths irregularly angular to hexagonal, 2 to 3 to the mm.; edges thin, white when fresh, becoming discoloured yellow; spores hyaline, smooth, oblong 5μ by 2μ to 3μ; hyphae 3μ to 6μ.

Distribution.—Found on dead wood around Durban by the writer.

This fungus is recognised by its thin flexible pileus and shallow angular pores. The margin of the pileus is usually thin, undulate, and incurved on drying.

20. *Polyporus durbanensis*, sp. n.

Plants annual, sessile or effused reflexed; pileus dimidiate, imbricate, applanate to conchate, laterally connate, 1 cm. to 3 cm. by 0·5 cm. to 2·5 cm. by 0·1 cm. to 0·3 cm., coriaceous, tough, becom-

ing firm and rigid in drying; surface pearl to lead or ash grey, finely tomentose pruinose, undulating, smooth becoming scabrid and fuliginous in places; context 0·5 mm. to 1·5 mm. white to discoloured, firm, corky; tubes 0·5 mm. to 1·5 mm. long; mouths irregular, angular, 4 to 5 to the mm.; edges thin, entire, grey changing to yellowish; spores hyaline, globose to oblong, 4μ diam.; hyphae 4μ to 5·5μ.

Distribution.—Known only from around Durban where it was collected on dead logs by the writer. (Type in Natal Herb. P. v. d. B., No. 896.)

21. *Polyporus trichiliae*, sp. n.

Plants annual, sessile, or effused reflexed; pileus dimidiate, conchate, densely imbricate, laterally connate, 0·5 cm. to 3 cm. by 1 cm. to 2 cm. by 0·1 cm. to 0·9 cm.; rigid and brittle when dry; surface creamy white to ochraceous, finely tomentose, rugulose; context 1 mm. to 4 mm. thick, creamy white, firm, corky; tubes 1 mm. to 3mm. long; mouths minute, subrotund to irregular, 5 to 6 to the mm.; edges thick becoming thin, chamois coloured to cinnamon; spores hyaline, smooth, ellipsoid, 5·5μ to 7μ by 3·7μ; hyphae hyaline, simple 3·6μ to 4μ.

Distribution.—Known from a single collection on *Trichilia emetica* at Durban by the writer. (Type in Natal Herbarium. P. v. d. B., No. 897.)

22. *Polyporus immaculatus*, Fries.

Pileus sessile, soft, fleshy when fresh, drying fragile, dimidiate. 10 cm. by 6 cm. by 0·8 cm., somewhat decurrent at attachment: surface white becoming greyish in old specimens, smooth, not encrusted; context 2 to 4 mm., white becoming discoloured, soft, fragile and crumbling when dry; tubes pure white 1 mm. to 3 mm. long; pores subrotund to irregular, 5 to 6 to the mm.; edges entire, white; spores (teste Lloyd) allantoid, cylindrical, curved, 1μ by 5μ; the under surface in some specimens is irregularly cracked.

Distribution.—Eastern Cape Forest Conservancy on *Podocarpus* log.

The crumbly context combined with the entire plant being white when fresh will assist in recognising this fungus.

23. *Polyporus robiniophila* (Murr), Lloyd.

Pileus sessile, dimidiate, often decurrent behind; 5 cm. to 17 cm. by 4 cm. to 7 cm. by 0·9 cm. to 4 cm.; surface milky white, discoloured with age, azonate, finely pubescent; margin thick; context white 0·5 mm. to 3·7 mm. soft corky; tubes 1 mm. to 5 mm. long, white, becoming yellowish; mouths circular to angular, 4 to 6 to the mm.; edges thick, entire, white; spores globose to pyriform, hyaline, smooth, guttulate 5·5μ to 8μ diam.; hyphae 4μ to 8μ diam.

Distribution.—Found saprophytic on dead logs around Durban by the writer. Mr. G. C. Lloyd remarks that the context is more firm in my specimens than it is in the American form.

24. *Polyporus luteus*, Nees.

Pileus stipitate, spathulate to flabelliform 1·8 cm. to 8·5 cm. by 2 cm. to 5 cm. by 0·3 cm. to 0·7 cm., firm to more or less flexible; surface glabrous, zoned, yellow to dark-brown; context 1 mm. to 3 mm. thick, white, fibrous, corky, firm; tubes 1 mm. to 2 mm. long, white to yellowish within; mouths minute, circular, 5 to 6 to the mm.; edges entire, white to yellowish, shining; stipe lateral 1 cm. long by 0·5 cm. to 1 cm. diam., disciform.

Distribution.—Recorded by W. Haygarth from the Ngoye Forest, Zululand.

25. *Polyporus sanguineus* (Linn), Fries.

Pileus coriaceous, sessile, or attached by a reduced base and substipitate, varying dimidiate, flabelliform, reniform, conchate or circular and depressed in the centre, often imbricate and laterally connate, 2·5 cm. to 7 cm. by 6 cm. to 10 cm. by 0·1 cm. to 0·8 cm.; surface bright red, fading in old specimens to pure white, tomentose to glabrous, zoned or azonate; context 0·9 mm. to 3 mm. thick, soft and floccose, red to yellowish-red, zoned or azonate; tubes 0·3 mm. to 1 mm. long, concolorous; mouths angular or circular 4 to 6 to the mm.; edges entire, bright red, fading like surface; spores hyaline, globose; hyphae 3·7μ to 6μ diam.

Distribution.—A common saprophyte on dead logs and stumps and observed growing on live *Aloe* sp. Distributed throughout the Union.

The plant is recognised by its red colour throughout. Another species with similar colour is *P. cinnabarinus* Jacq. ex Fr., which appears to differ from *P. sanguineus* primarily in being thicker and never substipitate.

The stipe varies from a mere attenuation to 2 cm. long.

26. *Polyporus cinnabarinus* (Jacq.) Fr.

Pileus annual, at times reviving, sessile to somewhat reflexed, dimidiate to laterally extended, leathery, tough, becoming firm and rigid, 3 cm. to 7·5 cm. by 2·5 cm. to 5 cm. by 0·5 cm. to 1·5 cm.; surface azonate to indistinctly zoned, orange to cinnabar-red, paling in old specimens like *P. sanguineus*, velvety, tomentose to glabrous; context zoned, soft corky, fibrous, red to yellowish red, 0·4 cm. to 1·3 cm.; tubes 0·5 mm. to 1 mm. long, concolorous; mouths 3 to 5 to the mm. subrotund to angular; edges entire, cinnabar red.

Distribution.—Found around Durban and in Eastern Cape Forest Conservancy, by the writer.

This fungus is similar to *Polyporus sanguineus* and differs only in being thicker and having its context more strongly zoned. Several collections of *P. sanguineus* had specimens intergrading into this.

27. *Polyporus occidentalis*, Klotzsch.

Pileus sessile, or effused reflexed, coriaceous to firm and rigid, dimidiate, applanate, frequently imbricate, 6 cm. to 13 cm. by

2 cm. to 8 cm. by 0·1 cm. to 1 cm.; surface concentrically sulcate, zoned, densely velvety tomentose or hirsute, varying fawn to buff, becoming grey with age, at times tuberculate; context 0·5 mm. to 3 mm., shining, yellow, fibrous, corky, to sub-woody; tubes 1 mm. to 4 mm. long, yellow within; mouths subrotund to irregular, unequal, 1 to 3 to the mm.; edges thick becoming thin and somewhat lacerate, pure white when young becoming yellow as the plant matures; spores hyaline, allantoid, 2μ by 7μ; hyphae 3μ to 7μ diam.

Distribution.—An exceedingly common fungus on dead stumps and logs. Recorded from Eastern Cape Forest Conservancy by J. D. Keet; common around Durban, by the writer; from Eshowe by Ridgeway; midlands of Natal, by the writer; G. Hobbs, at Howick, Natal.

P. lanatus Fr. is hardly specifically distinct from *P. occidentalis*, and probably but a form of it; *P. helvolus*, Fr. differs from *P. occidentalis* in somewhat larger pores, but this is not sufficient to make a species; *Trametes devexa*, Berk., is but a thick (1 cm. or more) trametoid form of *P. occidentalis*, and may occur in the same collection

Forms with more daedaloid pores have also been observed.

28. *Polyporus leoninus*, Klotz.

Pileus sessile or effused reflexed, dimidiate, imbricate, laterally connate 3·7 cm. to 13·5 cm. by 3 cm. to 7 cm. by 1·5 cm.; surface covered with a dense mat of coarse branched interwoven fibrils, light to fawn coloured; context 1 mm. to 2 mm., a thin, fibrous layer above tubes, merging in the mat of fibrils; yellowish buff; tubes 3 mm. to 4 mm. long, yellowish buff; mouths 1 to 2 to the mm.; angular; edges thin, irpiciform.

Distribution.—Found by H. J. Poss at Illovo, Natal; by the writer at Durban, Natal, and Umfolosi, Zululand.

The plant is recognised by the thick dense mat of coarse fibrils covering the upper surface of the pilei and by the irpicoid edges of the tubes.

29. *Polyporus mollicarnosus*, Lloyd.

Pileus annual or persisting a second season, circular, 38 cm. in diam., concave above; surface soft, pale buff to bluish green, smooth, undulating; context soft, spongy, floccose, buff to yellowish-buff 1 cm. to 5 cm. thick; tubes long, 0·5 cm. to 3 cm., buff coloured; mouths reseda green, irregular, angular to elongated; spores (teste Lloyd) smooth, very pale colour, truncate, 8μ by 12μ to 14μ; hyphae 4μ to 11μ.

Distribution.—A single specimen collected at Durban, Natal.

In its soft spongy context the fungus resembles *P. colossus*, but differs from it in its habit, surface, long pores, spore characters, and colour of context.

It is evidently normally an annual, though in part a second pore layer had formed over the first.

30. *Polyporus colossus*, Fries.

Plants large, light, annual, sessile, or substipitate; pileus pulvinate, 32 cm. by 23 cm. by 4 cm. to 8 cm.; surface azonate, covered with a thin cuticle which becomes fissured, yellow fading to lighter, soft to firm corky; margin thick, rounded; context 1 cm. to 6 cm., floccose, soft spongy to corky, yellow; tubes 0·3 cm. to 1 cm. long, soft, becomes discoloured yellow within; mouths subrotund to angular, 2 to 3 to the mm.; edges entire, yellow in herbarium specimens; spores (teste Lloyd) coloured, ovate, apiculate, truncate, rough, 12μ by 20μ; hyphae 4μ; stipe 3 cm. long.

Distribution.—Recorded from Pretoria district, Transvaal, by the Rev. N. Roberts (Herb. Div. Botany, 2043).

This plant is described as sessile, but the specimen above mentioned from which the description is taken and which was substipitate is surely the same. Recognisable by large, light pileus.

31. *Polyporus conchatus*, Lloyd.

Plants effused reflexed to entirely resupinate; pileus conchate, 1 cm. to 6 cm. by 0·5 cm. to 1·5 cm. by 0·1 cm. to 0·5 cm.; surface pale buff, becoming darker, uneven; context firm, hard, buff with pinkish spots, or pinky tint throughout, 1 mm. to 4 mm.; tubes, 0·5 mm. to 1·5 mm., concolorous; mouths subrotund to irregularly angular, unequal, 2 to 3 to mm. elongated on effused portion; spores hyaline 3·7μ to 5·5μ by 7·4μ to 9·3μ; hyphae 4μ to 5μ diam.; setae none.

Distribution.—Found by the writer at Klapmuts, Cape Province, on stump of *Populus* and known only from this collection. The pinkish buff colour of context is peculiar. The plant would also be looked for under *Trametes*. (Cotype in Natal Herbarium, P. v. d. B., No. 358.)

32. *Polyporus arenosobasus*, Lloyd.

Plants annual, stipitate; pileus circular, 8 cm. diam.; surface with a thin pellicle, fawn coloured changing to sepia, rugulose; context 0·1 cm. to 1 cm., fibrous, corky, firm, light yellowish; tubes 1 mm. to 3 mm. long, decurrent on stalk; mouths subrotund to irregular, 3 to 4 to the mm.; edges thin, entire; spores not found; hyphae 6μ to 7·5μ diam.; stalk arising from a false sclerotium consisting of agglutinated sand; true stalk short, about 1·8 cm. diam.; false sclerotium 5 cm. long by 3 cm. to 4 cm. diam.

Distribution.—A single collection at Durban, Natal, by J. B. Leslie. (Type in Natal Herb., No. 710.)

The plant differs from others recorded in South Africa in its false sclerotium. *Polyporus tuberaster*, Pers., a native of Europe, has a similar false sclerotium. Here, as in *P. arenosobasus*, the false sclerotium is composed of sand particles cemented together into a hard body by the mycelial threads of the fungus.

33. *Polyporus sulphureus* (Bull.), Fries.

Pileus sessile or substipitate by a reduced base, dimidiate to flabelliform, densely and closely imbricate, connate, fleshy and soft

when fresh becoming more firm and rigid on drying, 7 cm. to 20 cm. by 4 cm. to 16 cm. by 0·5 cm. to 3 cm.; surface finely tomentose to glabrous, fleshy white to lemon or orange yellow; margin undulate to lobed; context white to yellow, of a cheesy consistency and friable when dry, 0·3 cm. to 2·7 cm. thick; tubes 1 mm. to 4 mm. long, readily produced on any part of the fungus according to situation and position; mouths angular to somewhat irregular, 2 to 4 to the mm.; edges entire, yellow or white; spores hyaline, subglobose to oval; hyphae 7μ to 19μ diam.

Distribution.—Observed not uncommonly as a wound parasite on trunks of *Quercus* in the Stellenbosch district and around Cape Town by the writer and in the same localities on *Eucalyptus* stumps and in fire wounds on live *Eucalyptus* trees; collected at Knysna by J. D. Keet.

The plant is recognisable by the densely imbricated pilei; fleshy nature when fresh, soft cheesy and friable consistency of context and the ease with which pores develop on almost any part. The writer has frequently seen the plant growing without showing any trace of yellow, but the other characters are sufficiently distinct to aid in recognition. Petch records from Ceylon this fungus to be brick-red in colour, and this has also been observed in some South African specimens, though it appears to be uncommon here.

34. *Polyporus anebus*, Berk.

Pileus sessile, imbricate, dimidiate, decurrent behind, at times somewhat attenuated at attachment, 2 cm. to 5·5 cm. by 2 cm. to 3·5 cm. by 0·2 cm. by 0·5 cm., firm and rigid; surface hard, dark fawn, indistinctly zoned, minutely pubescent, undulating and smooth to rugulose; context fibrous and corky, pale yellow to yellow brown; 1 mm. to 2 mm.; tubes 1 mm. to 3 mm.; mouths cinnamon coloured, subrotund 5 to 6 to the mm.; edges entire, cinnamon coloured; spores globose, hyaline, smooth, $3{\cdot}7\mu$ diam.; hyphae 4μ to 7μ; setae none.

Distribution.—Found by W. Haygarth in the Ngoye Forest, Zululand.

35. *Polyporus nigrolucidus*, Lloyd.

Plants terrestrial annual, stalked; pileus circular, depressed in centre, rarely reniform, 4 cm. to 9 cm. diam. by 5 cm., surface black, laccate, rugulose; context whitish to brown, 1 mm. to 3 mm. thick, soft; tubes 1 mm. to 3 mm. long, white within; mouths subrotund to angular 5 to 6 to the mm.; edges thin, entire, white, becoming discoloured; spores coloured, apiculate, truncate, 4μ to $5{\cdot}5\mu$ by 6μ to $7{\cdot}5\mu$; hyphae $5{\cdot}5\mu$ to $7{\cdot}5\mu$; stalk central, rarely somewhat excentric or lateral, or deeply rooted, 12 cm. to 20 cm. long by 5 mm. to 7 mm. diam., interior soft.

Distribution.—Found at Durban, Natal, by J. M. Wood, and collected here also by the writer.

Distinguished by black laccate surface of pileus and stalk. (Type in Natal Herbarium, No. 412.) In young specimens the

surface of the pileus is frequently dark chestnut brown in part and in a few specimens the main stalk branched below the soil.

36. *Polyporus mastoporus*, Lev.

Pileus sessile or effused reflexed to laterally stipitate; surface horny encrusted, hard and laccate with a dark chestnut brown varnish, concentrically sulcate; context fibrous, corky, dark brown, 1 mm. to 5 mm., often separated into an upper softer and lighter region and a lower, dark coloured and harder region just above tubes; tubes 0·5 cm. to 2 cm. brown, hard and compact, becoming stuffed with white; mouths circular, 4 to 5 to the mm. edges entire, purplish brown; spores not found, according to Lloyd truncate, smooth, coloured 5μ by 8μ; hyphae $3{\cdot}5\mu$ to 5μ.

Distribution.—Recorded by W. Haygarth from the Ngoye Forest, Zululand.

This fungus is distinguished by its hard, compact, purple brown tubes and pore mouths, in which characters it differs from *P. lucidus;* it is also more woody than *P. lucidus* with a thicker and harder crust.

37. *Polyporus lucidus* (Leys), Fries.

Plants varying, substipitate, stipitate or sessile; pileus circular, dimidiate or reniform, applanate, imbricate and connate, corky when fresh, becoming woody on drying, 10 cm. to 25 cm. by 8 cm. to 30 cm. by 1 cm. to 4 cm.; surface covered with a thin crust, yellowish to dark chestnut brown, or red, laccate, concentrically sulcate, at times tuberculate, conidial bearing; margin entire to undulate, acute; context whitish to brown, 0·5 cm. to 3 cm. thick, duplex and usually separated into an upper light coloured and softer region and a lower darker and firmer region above the tubes, but frequently of the same colour and texture throughout, often hard, concentrically banded; tubes 0·3 cm. to 1·5 cm. long, brown within; mouths circular to angular, 3 to 4 to the mm., white becoming yellowish or brown, darker on being bruised; spores ovoid, yellowish brown, smooth to punctate and decidedly rough, apiculate, truncate, 9μ to 11μ by 5μ to $7{\cdot}4\mu$; hyphae 4μ to 8μ diam.; stipe absent or present, central to lateral, up to 8 cm. long, laccate like the crust.

Distribution.—A common fungus on live *Salix* sp. around Pretoria, by H. F. Cuff; on live *Acacia* sp. in the same locality; on live *Poinciana regia* around Durban, Natal, by the writer; by J. D. Keet in Eastern Cape Forest Conservancy on live *Olea verrucosa*, dead *Ptaeroyxlon utile* and dead *Zizyphus mucronata;* T. R. Sim on live *Acacia mollissima* in midlands of Natal; on *Albizzia amara* at Durban by the writer; at Howick, Natal, by Geo. Hobbs.

P. fulvellus, Bres. and *P. sessilis*, Murr. Lloyd are considered synonymous and to be sessile forms of it. Lloyd described the South African substipitate form under the name *P. capense*, Lloyd. *Polyporus curtisii*, Berk. is very similar to *P. lucidus*, but considered specifically distinct by most mycologists. The difference is

recorded as being in the truncate margin of this species and that the varnish on the surface is not persistent but disappears and mature plants are ochre yellow.

In some young specimens of *P. lucidus* from a willow stem the margin of the pileus was practically white and the surface of the same colour, the red varnish evidently not yet having formed.

The fungus is often merely saprophytic but frequently becomes semi-parasitic and causes a rot in the trunks of attacked trees. In the "South African Journal of Science," Vol. XIII, 1916, pp. 506-515, the writer described the rot of *Salix* trees caused by this fungus. It is doubtful if *Polyporus resinaceus*, Boudier, can always be distinguished from *P. lucidus*. The pileus in the specimen seen by me was broadly attached, pulvinate and thicker than *P. lucidus*, but in main characters it agrees with this fungus.

38. *Polyporus tabacinus*, Mont.

Pilei sessile, conchate, thin, flexible when fresh, often imbricate, decurrent behind, 1·9 cm. to 7 cm. by 2 cm. to 4 cm. by 0·2 cm. to 0·5 cm.; surface concentrically zoned with raised zones, velvety with thick coat of fine hairs, dark chestnut brown; context scanty, about 0·3 mm., fibrous, chestnut brown; tubes 1 mm. to 1·5 mm. long, lighter than context; mouths angular 4 to 6 to the mm.; edges thin, dark coloured, brownish drab; setae present, dark brown, 21μ to 28μ long, tapering to a point.

Distribution.—Found by W. Haygarth in Ngoye Forest, Zululand.

Differs from other fungi described in this paper in the colour and thick velvety pad on the surface. *P. iodinus*, Mont, is close to *P. tabacinus*, and differs in the pore mouths being somewhat larger. *Polystictus spadiceus*, Jungh. differs from *P. tabacinus* only in being firmer and is considered synonymous.

39. *Polyporus patouillardii*, Rick.

Pileus sessile, applanate, 5 cm. by 5 cm. by 0·5 cm. to 3 cm.; surface with a thin reddish black crust, rugulose, hard; context dark brown, brittle, 1 mm. to 2mm. thick, shining; tubes 3 mm. to 7mm. long, yellowish brown, with rigid, coloured hyphae in the walls, simple to bipid; mouths minute, subrotund 3 to 4 to the mm.; edges thick, entire, creamy white to yellowish; spores hyaline in this specimen which is immature (teste Lloyd), elliptical, pale coloured, 4μ to 6μ; setae brown, scattered, projecting 18μ to 24μ, 10μ diam. in thickest part; hyphae 4μ to 8μ.

Distribution.—Found on live *Scolopia mundii*, in Eastern Cape Forest Conservancy, by J. D. Keet.

The dark brown brittle context combined with the presence of rigid coloured hyphae in the pore walls would aid in the recognition of this fungus. In the South African collection the rigid brown hyphae in the pore walls and the setae are both present, but this is evidently a varying character, for Mr. C. G. Lloyd records specimens from Australia where both the setae and the rigid coloured hyphae were absent.

40. *Polyporus ochro-porus*, sp. n.

Pileus sessile, convex above, thickest behind, 5·5 cm. by 4 cm. by 0·5 cm. to 2·5 cm.; surface brown, soft, minutely pubescent; context 0·5 cm. to 2·3 cm., soft, tough, yellowish-brown above, dark-brown and brittle below, zonate, shining; tubes 1mm. to 7 mm. long, ochre yellow, brittle, rigid brown hyphae in the walls; mouths angular, averaging 2 to the mm., edges thin, entire to dentate, concolorous with tubes, changing to brown; spores lightly coloured, subglobose to elliptical, 4μ to 5μ by 5μ to $7·5\mu$; setae scanty 15μ to 21μ long by 4μ to 7μ diam.; hyphae 4μ to 8μ.

Distribution.—A single collection from a stump in Eastern Cape Forest Conservancy was made by the writer. (Type in Natal Herbarium, P. v. d. B., No. 115.)

The plant is evidently related to *P. patouillardii*, but with different surface, different colour of mouths, duplex context, larger pore mouths and thinner setae. The rigid hyphae in the walls of the tubes are less abundant than in the specimens of *P. patouillardii*.

41. *Polyporus gilvus* (Schw.), Fries.

Pileus sessile, effused reflexed to entirely resupinate, often imbricate, dimidiate, 3 cm. to 11 cm. by 2 cm. to 4 cm. by 0·2 cm. to 2 cm., coriaceous to firm and rigid, annual or reviving; surface yellowish-brown or reddish-brown, often more or less zoned, pubescent when young, soon becoming glabrous and usually rough with stiff projections; context yellowish brown, corky or woody, at times distinctly zoned, 0·1 cm. to 1·5 cm. thick; tubes 1 mm. to 5 mm. long, reddish brown; mouths circular to angular, 6 to 7 to the mm., edges entire, reddish brown or darker; setae present, dark brown, $19·8\mu$ to $26·4\mu$ long, tapering to a point; spores hyaline, smooth, ellipsoid, 3μ to 4μ by 5μ to 6μ.

Distribution.—A common saprophyte on dead branches, stumps and logs. Found at Fountains, Pretoria, Transvaal, by the writer; on dead *Quercus* branch in Eastern Cape Forest Conservancy by J. D. Keet; on *Acacia melanoxylon* in the Willowdale plantation, Transkei by Kunn; common around Durban, Natal, by the writer; at Howick, Natal, by G. Hobbs.

The surface of the plants varies from almost smooth to exceedingly rough. The rough forms may be classified as *P. scruposus*, Fr., but this is not specifically distinct from *P. gilvus*, the surface varying in one and the same collection from almost smooth to rough. *Trametes isidioides*, Berk. reported from Natal and the Cape is synonymous with the "scrupose" form of *P. gilvus*.

42. *Polyporus fruticum*, Berk. and Curt.

Pileus sessile, generally encircling twigs, 3·7 cm. diam. by 2 cm. thick, or larger, soft spongy, annual or reviving; surface azonate, tomentose, yellowish buff to brown; context rusty-brown, soft spongy, 0·3 cm. to 1·4 cm., with region next to tubes firmer; tubes 1 mm. to 2·5 mm., rusty-brown, firm; mouths angular to

irregular, 3 to 4 to the mm.; edges thin rusty-brown; spores subglobose, smooth, pale coloured $3{\cdot}7\mu$ diam.; hyphae $2{\cdot}8\mu$ to $7{\cdot}4\mu$ diam.; in upper more loose region richly septate and branched, in firmer region more compact and on the average thinner.

Distribution.—Recorded by W. Haygarth, from Krantzkloof, Natal, on a Rubiaceous plant.

Recognisable by spongy pileus, its usual habit of encircling branches and the contrast between the soft spongy upper context tissue and the firm tubes.

43. *Polyporus vinosus*, Berk.

Pileus thin, sessile, dimidiate, often imbricate, laterally connate and decurrent, 1 cm. to 2·5 cm. by 0·7 cm. to 1·7 cm. by 0·5 cm to 0·7 cm.; surface velvety to glabrous, vinous purple; context vinous purple, 5 mm. or less thick, corky, firm; tubes short, 1 mm. or less; mouths angular, 5 to 7 to the mm.; edges thin, entire, vinous purple; spores hyaline, allantoid, 4μ to $4{\cdot}5\mu$ by $1{\cdot}5\mu$; hyphae $3{\cdot}5\mu$.

Distribution.—Found in Natal on old stumps at Schroeders and around Pietermaritzburg by the writer.

The plant is recognisable by its vinous purple colour and short tubes.

44. *Polyporus aratus*, Berk.

Pileus sessile, coriaceous to firm and rigid, dimidiate, decurrent behind, less frequently imbricate, 3·5 cm. to 20 cm. by 2 cm. to 9 cm. by 0·2 cm. to 2 cm.; surface fawn coloured to olive, glabrous, smooth or dotted with tubercles and rough, often concentrically zoned or sulcate with raised ridges; context, 0·5 cm. to 1·5 cm., dark olive brown, zoned, corky, firm; tubes short, 0·2 mm. to 0·4 mm.; mouths circular to angular, 3 to 4 to the mm.; edges thick or thin, darker fawn than surface, changing to a dark olive brown; spores hyaline, $5{\cdot}5\mu$ to $7{\cdot}4\mu$ by $3{\cdot}7\mu$; hyphae $3{\cdot}4\mu$; setae none.

Distribution.—A common fungus on dead logs or stumps. Recorded by J. D. Keet and the writer in the Eastern Cape Forest Conservancy; W. Haygarth, in the Ngoye Forest, Zululand; the writer around Durban and at Schroeders, Natal; G. Hobbs, at Howick, Natal.

A variable fungus. Stalked forms have been recorded though none have thus far come to the writer's notice. The fungus perhaps is better known under the name *P. luteo-olivaceous*, Berk., which is regarded as synonymous.

45. *Polyporus phocinus*, Br. and Berk.
Polystictus phocinus, Br. and Berk.

Plants thin, largely or entirely resupinate, effused, with thin, coriaceous, reflexed pilei, about 0·5 mm. thick; surface zoned, velvety tomentose, slightly furrowed, umber brown; tubes about

0·3 mm. long; mouths subrotund to angular, 2 to 3 to the mm.; edges thick, entire, stone colour (greyish fawn); spores hyaline, smooth, 3μ to 4μ by 4μ to 7μ.

Distribution.—Common on logs around Durban, collected by the writer.

Recognised by its extreme thinness and umber brown, zoned, velvety surface.

The plant is described as "subflabelliform" but all the specimens seen by the writer have been largely resupinate, but in spite of this different habit they are referred here. Even in the resupinate region the fungus is frequently not attached to the substratum by its entire under surface, but by "nodular" swellings which arise at irregular intervals.

P. caperatus, Berk., is close to the above but thicker, and this appears to be the main and only distinction between the two.

46. *Polyporus flexilis*, sp. n.

Plants effused-reflexed; pileus coriaceous, imbricate, tough, at times conchate, laterally extended, connate, 1 cm. to 7 cm. by 1 cm. to 1·5 cm. by 0·1 cm. to 0·5 cm.; surface with a brown velvety to hirsute pubescence, azonate; margin thin, acute, often turned upwards; context soft and spongy to corky, 1 mm. to 4 mm., umber brown, shining, fibrous; tubes 0·3 mm. to 1 mm. long, concolorous with context, elongated on effused portion; mouths subrotund to elongated or angular, 2 to 3 to the mm.; edges entire, thin, brown; hyphae simple 4μ to 5μ.

Distribution.—Found at Pietermaritzburg, Natal, on log, by the writer.

The plant is related to *Polystictus zelanicus*, and differs from *Trametes protea*, Berk., in colour of context. (Type in Natal Herbarium, P. v. d. B., No. 810.)

47. *Polyporus subpictilis*, P. Henn.
Polystictus subpictilis, P. Henn.

Pileus sessile, thin, coriaceous, attenuated at back, applanate, flabelliform, 2 cm. to 4 cm. by 3 cm. by 0·03 cm. to 0·2 cm.; surface hard, brown, with raised concentric zones; margin thin, undulate crenate; context yellowish brown 0·25 mm. to 0·5 mm., fibrous, tough; tubes 0·25 mm. to 1·5 mm. long; mouths 3 to 4 to the mm. angular; edges thin, entire, dark brown; spores not found; hyphae 4μ to 5μ diam.; setae none.

Distribution.—Found in Eastern Cape Forest Conservancy by J. D. Keet.

From *P. anebus* it differs in being thinner, flexible, and having raised concentric zones.

48. *Polyporus subradiatus*, Lloyd.

Pileus sessile, dimidiate, firm, decurrent behind, 1·3 cm. to 3 cm. by 1 cm. to 2 cm. by 0·3 cm.; surface inconspicuously zoned, yellowish brown, smooth, velvety tomentose becoming glabrous, at times dark brown and more or less regulose; context yellowish

brown, 1 mm. to 2 mm., fibrous, corky; tubes 1 mm. or less; mouths subrotund, 5 to 6 to the mm.; edges entire, yellowish brown or dark brown; spores hyaline, elliptical, 5μ to 7μ by 3μ to $3{\cdot}7\mu$; hyphae 4μ diam.; setae absent.

Distribution.—Found by A. Roberts, on *Eucalyptus* log at Steynsdorp, Transvaal.

Distinguished from *P. aratus* by different context colour and from *P. subpictilis* by being thicker, velvety tomentose, and having on the average smaller and subrotund pore-mouths. The fungus was originally named by Mr. C. G. Lloyd from specimens forwarded him by Prof. A. Yasudu from Japan.

49. *Polyporus rusticus*, Lloyd.

Plants annual, sessile; pileus corky, firm, rigid, circular to dimidiate 1·5 cm. to 4 cm. by 0·5 cm. to 2 cm. by 0·2 cm. to 0·6 cm.; surface grey, rugulose, scrupose; context 3 mm. to 4 mm. fibrous, tough, corky, dark brown; margin acute, thick; tubes 1 mm. to 2 mm. long, lighter than context; mouths irregular, angular to elongated, approximating 2 to 3 to the mm. elongated as much as 2 mm.; edges thick, firm; spores (teste Lloyd) hyaline, cylindrical, obliquely apiculate, $3{\cdot}5\mu$ by 8μ; setae absent; hyphae 4μ diam.

Distribution.—Single collection from Pine stump at Klapmuts, C.P. made by the writer. (Cotype in Natal Herbarium, P. v. d. B. No. 387.)

The rough scrupose surface is peculiar. The pore mouths are frequently much elongated, and would suggest that the fungus may possibly occur in the lenzitoid form.

Fomes (Fr.) Gill.

Plants epixylous, typically perennial; pileus sessile, usually woody, rarely corky, effused reflexed to applanate or ungulate, rarely entirely resupinate; surface with or without a crust, often rimose; context white, purple or some shade of brown, most frequently woody, in some (*Fomes connatus*) corky; tubes in a definite layer, a new layer forming for each successive year of growth, the successive layers at times separated by context tissue; mouths circular or angular (never daedaloid, irpiciform, or lenzitoid), white, red, or brown; spores hyaline, or coloured, in a limited number truncate; setae absent or present.

The genus is characterised by the successive pore strata corresponding to the years of growth of the pileus; some perennial polypores are included in *Trametes* which see.

KEY TO THE SPECIES.

1. Context white, though darkening in old specimens, spores hyaline, setae absent.
   2. Tubes more or less concolorous with context.
   3. Pileus corky; successive layers of tubes separated by context tissue, mouths subrotund and glistening. *F. connatus* 1

3. Pileus woody; surface horny encrusted, hard, successive pore-layers not separated by context tissue. *F. hornodermus* 2
2. Tubes dull brick-red contrasting with white context. *F. geotropus* 3
1. Context coloured; spores hyaline or coloured; setae absent or present.
4. Context purple-brown, setae absent, spores hyaline. *F. melanoporus* 4
4. Context yellow-brown or dark brown but not purple.
5. Spores hyaline, setae present.
6. Pileus thin, less than 2 cm., setae abundant, spores 4μ to 6μ diam. *F. conchatus* 5
6. Pileus more than 2 cm. thick.
7. Spores large, 7μ to $7{\cdot}5\mu$ diam.; setae scanty. *F. robustus* 6
7. Spores 3μ to 4μ diam., setae scanty. *F. robinsoniae* 7
5. Spores coloured. Not truncate.
8. Setae absent.
9. Pileus thin, applanate, surface with raised concentric ridges, mouths 7 to 9 to the mm. *F. pectinatus* 8
9. Pileus large, ungulate or applanate, surface more or less rough and rimose; mouths 5 to 6 to the mm., spores subglobose 4μ to 5μ diam. *F. rimosus* 9
9. Pileus subresupinate, spores globose to elliptical, $3{\cdot}7\mu$ to 5μ or $3{\cdot}7\mu$ diam. *F. McGregori* 10
8. Setae present.
10. Pileus applanate, surface closely sulcate with raised ridges, velvety tomentose, pore mouths 8 to 9 to the mm. *F. senex* 11
10. Pileus applanate or ungulate; surface rimose and rough; pore mouths 5 to 7 to mm. *F. yucatanensis* 12
5. Spores coloured, truncate; setae absent.
11. Mouths bright yellow. *F. oroflavus* 13
11. Mouths white. *F. applanatus* 14

1. *Fomes connatus* (Weinm) Gill.

Pileus corky to woody, perennial, sessile, largely resupinate, effused-reflexed or imbricate, 4 cm. to 8 cm. by 8 cm. to 16 cm. by 1·5 cm. to 10 cm.; surface velvety tomentose to glabrous, not encrusted, white becoming yellowish or darker with age; context soft corky, white; tubes in distinct strata, 1 to 3 mm. long each season, and the successive strata separated from each other by a layer of context tissue; mouths angular, 4 to 5 to the mm.; edges entire white or yellowish, glistening, spores not found; hyphae $2{\cdot}5\mu$ to 4μ.

Distribution.—Found on live *Curtisia faginea* by J. D. Keet in the Eastern Cape Forest Conservancy.

The fungus can be recognised by the context tissue between the pore strata and the glistening of the mouths of the tubes. Often the tubes are more yellowish than the context tissue and the strata then show up especially well.

2. *Fomes hornodermus* (Mont) Cke.

Pileus hard, woody, perennial, sessile, dimidiate, plane above and convex below or ungulate 4 cm. by 7 cm. by 11 cm.; surface smooth, sulcate, dark-brown to black, horny encrusted and becoming rimose with age; context white becoming pale-umber, woody, 1 mm. to 4 mm. thick but often exceedingly scanty; tubes 4 mm. to 9 mm. long each season, white; mouths minute, subrotund, 3 to 4 to the mm.; edges entire, white to yellowish; spores hyaline, ovoid, $3{\cdot}7\mu$ to $6{\cdot}4\mu$ by 7μ to $9{\cdot}2\mu$; hyphae 4μ to $5{\cdot}5\mu$.

Distribution.—On undetermined host from Eshowe, Zululand, by G. W. Hyslop; on *Ocotea bullata* in Lusikisiki Forest, Pondoland (Herb. Div. Bot., Pretoria, No. 6936); from Rhodesia by C. Swynnerton.

The hard, horny encrusted surface combined with the hard white tubes and woody context serves to distinguish this fungus from others which may resemble it externally.

3. *Fomes geotropus*, Cke.

Pileus, large, hard and woody, up to 10 cm. thick, conchate; surface rough, concentrically sulcate, white to cream coloured; context corky to woody, white in fresh material changing to yellowish in herbarium specimens, 4 cm. thick; tubes 0·2 cm. to 1·5 cm. long each season, stratified (in one South African specimen the strata of successive years were separated from each other by context tissue), dull brick-red fading in older layers; mouths minute, subrotund 4 to 5 to the mm.; edges entire, bright coloured when fresh; spores hyaline, globose, thick walled, 7μ diam; hyphae $3{\cdot}7\mu$.

Distribution.—Recorded from Umtata, Pondoland, on live *Podocarpus* sp.; and by J. D. Keet from Knysna, on live *Ocotea bullata;* from Rhodesia by C. Swynnerton.

Recognised by the contrast in colour of context and tubes. The existence of layers of context tissue separating the pore-strata of successive years is not reported from elsewhere for this fungus and is probably merely a growth condition.

4. *Fomes melanoporus* (Mont) Cke.

The specimens of this plant found in Africa by the writer have all been resupinate and formed masses 9 cm. to 12 cm. or more across and 0·1 cm. to 1 cm. thick, with thin rounded or acute velvety margins; context purple to brown to dark reddish violet, shiny, fibrous, becoming very hard and horny, 2 mm. or more thick; tubes distinctly stratified, 2 mm. to 3 mm. long each season, purple-brown fading to lighter; mouths subrotund to angular 5 to 6 to the mm.; edges entire, reddish violet to smoky black,

fading out in old specimens to an almost grey; spores not found; according to Lloyd hyaline, smooth and about 3μ by 4μ; hyphae $3{\cdot}7\mu$ to $5{\cdot}5\mu$ diam.

Distribution.—Found by the writer at Schroeders and Crammond, Natal Province, on undetermined logs.

The plant is recognisable by its purplish brown, hard, context tissue and in fresh young specimens by the whole plant being smoky black, a colour unusual amongst *Fomes*. In regions of one collection there was context tissue between the successive pore strata.

The context colour in South African collections is somewhat lighter than type material. *Fomes cornu-bovis* described by Cooke from India is the same plant and he records it as forming large masses, such as the writer has observed.

5. *Fomes conchatus* (Pers), Gill.

Pileus perennial, woody, thin, effused reflexed, dimidiate to conchate, and at times entirely resupinate, 3·5 cm. to 10 cm. by 3 cm. to 8 cm. by 0·2 cm. to 1·3 cm.; surface yellowish to greyish brown becoming almost black with age, zoned or concentrically sulcate and when young tomentose, becoming glabrous with age; context yellowish-brown to dark-brown, 1 mm. to 5 mm. thick, woody; tubes indistinctly stratified, 1 mm. to 3 mm. long each season, concolorous; mouths subrotund 5 to 7 to the mm.; edges entire, yellowish-brown to dark brown; setae abundant, dark brown, 14μ to 28μ by 7μ; spores hyaline, globose, 4μ to 6μ; hyphae 2μ to $3{\cdot}5\mu$ diam.

Distribution.—Recorded by T. R. Sim on *Melia azedarach* at Pietermaritzburg, Natal; at Howick, Natal, by Geo. Hobbs; by J. B. Leslie and the writer around Durban; mostly on dead trunks and logs.

6. *Fomes robustus*, Karsten.

Pileus woody, perennial, sessile, ungulate (in maldeveloped forms, resupinate); surface hard, brown becoming black and rimose; context woody 1 mm. to 3 mm. thick, bright yellowish-brown; tubes 1 mm. to 2·5 mm. long each season, concolorous with context, becoming stuffed in older layers; mouths subrotund 5 to 6 to the mm.; edges thin, entire, yellowish-brown; spores globose, hyaline, 7μ to $7{\cdot}5\mu$ diam.; setae few, dark brown, 21μ to 28μ long, tapering to the point; hyphae 4μ.

Distribution.—Recorded by J. D. Keet in Eastern Cape Forest Conservancy on *Olea laurifolia* and *Xymalos monospora* (dead); K. A. Lansdell at Bulwer, Natal.

7. *Fomes robinsoniae* (Murrill), Lloyd.

Pileus perennial, woody, dimidiate, applanate, slightly decurrent behind, 10 cm. by 7 cm. by 1 cm. to 3 cm.; surface hard, yellowish-brown, sulcate, becoming dark coloured, often tuberculate and rough; context yellowish brown 1 mm. to 5 mm. thick, woody; tubes indistinctly stratified, 1 mm. to 3 mm. long each

season, concolorous with context, mouths subrotund approximating 4 to the mm.; edges entire, thick, brown; spores hyaline, globose, 3μ to 4μ diam.; setae scanty, straight to curved at apex; hyphae 4μ diam.

Distribution.—Found by J. B. Keet, Knysna, Cape Province, on *Gymnosporia peduncularis.*

Differs from *Fomes rimosus* in presence of setae and hyaline spores and from *Fomes robustus* in smaller spores; from *Fomes yucatanensis* it differs in its hyaline spores. None of the specimens seen by me were rimose. In the original description setae are said to be absent, and I believe Mr. C. G. Lloyd was the first who recorded them in this species.

8. *Fomes pectinatus* (Klotz) Cke.

Pilei thin, woody, perennial, sessile, imbricate, triquetrous, flabelliform or dimidiate, applanate, somewhat decurrent behind, 2 cm. to 12 cm. by 1·7 cm. to 9 cm. by 0·1 cm. to 0·4 cm.; surface repeatedly slightly sulcate with close concentric raised ridges, yellowish brown to brown, often somewhat tuberculate, velvety, becoming glabrous and black with age, not rimose; context thin, woody, 0·1 mm. or less thick, yellowish-brown to dark brown; tubes indistinctly stratified, 0·9 mm. to 1·2 mm. long each season, concolorous with context; mouths circular, 7 to 9 to the mm.; edges thin, entire, yellowish-brown to dark-brown; spores not found; setae none; hyphae $2{\cdot}8\mu$ to $3{\cdot}7\mu$ diam.

Distribution.—Recorded from Eastern Cape Forest Conservancy and Nottingham Road, Natal, by the writer.

Recognised by the thin pilei, with the closely concentric ridges on the surface.

9. *Fomes rimosus* (Berk.) Cke.

Pileus hard and woody, perennial, sessile, dimidiate, applanate to ungulate, frequently very large 3 cm. to 73 cm. by 3 cm. to 36 cm. by 1·5 cm. to 28 cm.; surface velvety and yellowish brown, concentrically sulcate, soon becoming glabrous, black and very much rimose and ragged; margin yellowish brown, velvety; context yellowish brown to rusty brown, woody, 0·5 mm. to 1·5 mm. thick; tubes in indistinct strata, 2 to 6 mm. long each season; mouths minute, circular, 3 to 6 to the mm.; edges entire, thick, yellowish brown to dark brown, velvety to rough; spores globose to slightly oval, $4{\cdot}35\mu$ to 5μ diam., rusty brown; setae none; hyphae 3μ to 4μ diam.

Distribution.—This is one of the commonest South African Polyporeae and has been found on a large number of different hosts. It is recorded by J. D. Keet from Eastern Cape Forest Conservancy on *Ptaeroxylon utile*, *Schotia latifolia*, *Rhus laevigata*, *Pleurostyla* sp., *Curtisea faginea*, *Scolopia mundii*, *Kiggelaria africana*, *Xymalos monospora*, *Olea laurifolia;* A. Legat on *Elœodendron croceum* at Knysna; from the Transvaal on *Acacia* sp.; undeter-

mined host by A. Hall (Herb. Div. Bot., Pretoria, No. 9751); from Karkloof, Natal, by E. Platt; also from Pondoland; Howick, Natal, by G. Hobbs.

Fomes badius, Berk. is considered as a smooth form of *F. rimosus* with lighter surface and larger pores than is typical for the latter, but it is not sufficiently distinct from it.

The fungus differs from *Fomes robustus* in its coloured spores and absence of setae and from *Fomes yucatanensis*, which it resembles externally, in the absence of setae.

It is one of the most serious forest fungi in South Africa, causing a "heart-rot" in the trees attacked. In the "Transactions Royal Society of South Africa," Vol. VI, p. 215, the "heart-rot" of "Sneeze-wood" (*Ptaeroxylon utile*) caused by this fungus is described.

10. *Fomes McGregori*, Bres.

Pileus subresupinate, woody, 2 cm. to 4 cm. thick; surface closely concentrically sulcate, brown and velvety becoming black and rough with age, context woody, dark-brown; tubes in distinct strata 1 mm. to 4 mm. long each season, deep-brown becoming filled with hyphae and lighter in colour; mouths subrotund to somewhat angular, 4 to 6 to the mm.; edges entire, dark-brown; spores subglobose to ellipetical, lighter brown, 3·7μ diam. to 3·7μ to 5·5μ; setae none.

Distribution.—Recorded by J. D. Keet in Eastern Cape Conservancy, on *Rhus laevigata*, *Scolopia mundii*, and *Trichocladus* sp.

In colour of context this is close to *F. pectinatus* from which it differs in its subresupinate habit; from *E. rimosus* it differs in its habit, darker context colour and colour of spores which are smaller and elliptical. The tubes are also shorter and the whole sporophore more closely grained. I doubt if *Fomes caryophylli*, Rac. is really different from above. The spores in the latter are given as globose and in the former as elliptical, but in specimens examined by me they varied from globose to elliptical, and for this reason they are referred as above.

11. *Fomes senex.* (Nees & Mont) Cke.

Pileus large, woody, perennial, sessile, applanate, broadly attached and decurrent behind; 5 cm. to 35 cm. by 3 cm. to 20 cm. by 0·3 cm. to 3 cm. surface closely concentrically sulcate with small raised ridges, at times tuberculate and rough, brown, hard, velvety tomentose, becoming glabrous and lighter with age; context scanty, 2 mm. thick, dark-brown, woody, tubes indistinctly stratified, 1 mm. to 1·5 mm. long each season, concolorous with or lighter than context; mouths minute, circular, 8 to 9 to the mm., edges entire, darker than tubes, velvety to touch; spores not found, according to Lloyd globose, 5μ diam. deeply coloured, hyaline when young; setae brown, 21μ to 28μ long tapering to a point; hyphae 3μ to 4μ.

Distribution.—Recorded by G. Thorncroft, Barberton, Transvaal; E. M. Doidge, on *Sizygium* sp. in the Woodbush, Trans-

vaal (Herb. Div. Bot., Pretoria, No. 1724); W. Haygarth, in the Ngoye Forest, Zululand; Mrs. Reynolds, at Pietermaritzburg, Natal; J. B. Leslie and the writer, around Durban, Natal.

This is quite a common plant in South Africa. It is a larger, thicker, and heavier plant than *F. conchatus*, and the surface closely sulcate with small raised ridges.

12. *Fomes yucatanensis* (Murr.) Sacc.

Pileus large, woody, perennial, sessile, dimidiate, applanate or ungulate, 6 cm. to 40 cm. by 4 cm. to 14cm. by 5 cm. to 13 cm.; surface at first velvety, yellowish-brown but later glabrous, dark-brown to black and soon becoming very rimose; context hard and woody, 0·4 cm. to 0·8 cm., yellowish-brown; tubes stratified 1·5 mm. to 3 mm. long each season, concolorous; mouths circular 5 to 7 to the mm.; edges entire yellowish-brown or darker, velvety to touch; spores subglobose to globose, yellowish-brown, 3μ to 5μ; setae present, dark-brown 17μ to 28μ long, tapering to a point.

Distribution.—Recorded in Eastern Cape Forest Conservancy on live *Olea* sp. by J. D. Keet; around Pretoria, Transvaal, by A. Roberts on dead branch; on live *Trema bracteolata* around Durban, Natal, by the writer.

Externally this plant is very similar to *F. rimosus*, from which it is, however, distinguished by the presence of setae. From *F. robustus* it differs in its smaller and coloured spores.

13. *Fomes oroflavus*, Lloyd.

Pileus perennial, sessile, applanate, 16 cm. by 10 cm. by 8 cm.; surface horny, encrusted, reddish, sulcate, conidial bearing; context dark-brown, corky to somewhat hard, 4 mm. or more thick; tubes 0·5 to 1 cm. long each season, brown, older becoming blocked up with hyaline hyphae; mouths circular, 4 to the mm., edges entire, bright yellow; spores yellowish-brown, truncate, obovate, echinulate, $7{\cdot}4\mu$ to 11μ by $7{\cdot}4\mu$ to 9μ; hyphae 3μ to $5{\cdot}3\mu$ diam.; setae none.

Distribution.—Recorded by P. J. Pienaar on *Podocarpus thunbergii* at Knysna, Cape. (Herb. Div. Bot., Pretoria, No. 2338.)

Except for the yellow pore mouths this plant is like *Fomes applanatus*. So far I have only seen the above recorded specimen and it is evidently not common. If it is merely a variation of *F. applanatus* it would appear strange that it should not be more common.

14. *Fomes applanatus* (Pers) Wallr.

Pileus frequently large, woody, perennial, applanate to ungulate, 10·5 cm. to 42 cm. by 10 cm. to 22 cm. by 2 cm. to 10 cm.; surface horny encrusted, greyish, reddish to drab-brown, sulcate, at time tuberculate, opaque to subshining, conidial bearing; context rusty to dark bay-brown, floccose, soft corky to hard, 0·5 cm. to 3 cm. thick; tubes in strata (the layers of successive years at times separated by context tissue), 0·5 cm. to 2 cm. long each season, dark-umber-brown, becoming stuffed with hyaline hyphae;

mouths minute, circular, 3 to 4 to the mm.; edges entire, white when fresh, dark-umber in old or bruised collections; spores obovate, truncate with thick walls, smooth to punctate or echinulate $6{\cdot}6\mu$ to 8μ by $8{\cdot}3\mu$ to 10μ; hyphae 3μ to 6μ.

Fomes vegetus (Fr.) Cke. is a form of *F. applanatus* with context tissue between the annual pore layers, but hardly a distinct species. It is a growth condition. *Fomes leucophaeus* (Mont) Cke. is a form with lighter surface colour. *Fomes australis* (Fr.) Cke., the name by which this fungus is perhaps better known in South Africa, is held to have a harder crust, scantier context, and longer pores than typical *F. applanatus*. These characters, however, intergrade and vary so much that it is difficult to know where and how to draw the line. I do not think it can be considered a distinct species. When growing at the base of trees and partly covered up with débris, a stipitate form of this fungus has often been met with. In form and shape they agree with *Polyporus gibbosus*, Nees, but only an examination of the type material of Nees can decide the identity of his fungus.

Fomes annularis, Lloyd, differs from typical *F. applanatus* in its ungulate, pendent pileus with concentric raised annular rings. It is a common form in South Africa. The form is peculiar amongst the Fomes and it is probably best considered as merely a growth variety of *F. applanatus*.

Distribution.—Fomes applanatus is the commonest species of the genus in South Africa, and occurs throughout the country. In the Eastern Cape Conservancy J. D. Keet collected it on *Olea laurifolia*, *Rhus laevigata*, *Curtisea faginea*, *Acacia mollissima*, *Celtis kraussiana;* W. Haygarth has it from the Ngoye Forest, Zululand. In the Lusikisiki Forest, Pondolond, it has been found on *Olea laurifolia* (Herb. Div. Bot., Pretoria, No. 6940); in the Transvaal on live *Pyrus communis*, by the writer; in Natal it has been found on *Podocarpus* sp. in the Hlatikulu Forest, and also on stumps of *Acacia mollissima* and on live *Albizzia fastigiata* at Durban.

Typical specimens of var. "annularis" are from *Olea laurifolia* at the Kologa Forest, Stutterheim, Cape, and on the same host in Pondoland. W. Haygarth collected it also in the Ngoye Forest, Zululand, and I. B. Pole-Evans obtained it on *Cunonia capensis* at the National Botanic Gardens, Cape Town.

The fungus is a facultative parasite and causes considerable damage to *Olea laurifolia* and other trees.

In the "South African Journal of Science," Vol. XIV, p. 485, the writer dealt with the effect of this fungus on *Olea laurifolia*.

Trametes, Fries.

Plants epixylous, annual or perennial, sessile; pileus corky to woody, flexible to firm; context white, yellow, lilac, olive or some shade of brown, corky, tough to woody, descending into and forming the walls of the tubes; tubes typically appear sunken to unequal depths in context tissue so that their bases are not in a

continuous line; mouths circular to angular, rarely becoming daedaloid (e.g., *Trametes obstinatus*), edges entire, rarely toothed; spores hyaline; in *Tr. albotexta* lightly coloured.

The main characteristics of the genus are the unequal depths of the tubes and the homogeneous texture of context and tube tissue. These characters combined give the tube an appearance of being sunk in the context tissue. Some difficulty may at time be experienced in deciding between *Trametes* and *Polyporus*, and some species of the latter (cf. *P. occidentalis*) at times show thick trametoid forms.

KEY TO THE SPECIES.

1. Context white.
   2. Pileus one cm. or less thick.
   3. Surface black, discoloured with age but black spots usually remaining. *Tr. cingulata* 1
   3. Surface white or whitish, minutely pubescent.
      Pileus applanate. *Tr. glabrescens* 2
      Pileus effused-reflexed or largely resupinate. *Tr. varians* 3
   2. Pileus more than 1 cm. thick.
   4. Pileus rarely imbricate; spores large, guttulate. Vide *P. robiniophila*, p. 262.
   4. Pilei imbricate, spores subglobose, $5{\cdot}5\mu$ to 8μ diam.
   5. Surface hard. *Tr. sycomori* 4
   5. Surface soft, densely tomentose when young. *Tr. lactinea* 5
1. Context olive brown. *Tr. protea* 6
1. Context purple. *Tr. violacea* 7
1. Context lilac-mauve. *Tr. griseo-lilacina* 8
1. Context brown but not olive or purple.
   6. Setae present. *Tr. keetii* 9
   6. Setae absent.
      Context reddish brown.
   7. Tissue of tubes white, hymenium red. *Tr. albotexta* 10
   7. No contrast in colour of context, hymenium and pore walls as above.
   8. Surface with a dense hirsute or hispid reddish brown pubescence. *Tr. hispida* 11
   8. Surface creamy white to fuliginous minutely pubescent. *Tr. moesta* 12
1. Context yellow.
   9. Pileus ungulate. *Tr. subflava* 13
   9. Pileus not ungulate.
   10. Surface velvety tomentose; pores becoming daedaloid; pileus frequently large and woody. *Tr. obstinatus* 14
   10. Pores not becoming daedaloid.
   11. Surfaces of pileus with a conspicuous hairy covering.
   12. Tomentum villose, soft, cinnamon brown. *Tr. tomentosa.* 15

13. Tomentum hirsute to hispid, reddish brown to grey.
14. Pileus inseparably attached to substratum; context in part at least very hard and woody. *Tr. ochrolignea* 16
14. Pileus not as above, context usually corky.
Vide *P. occidentalis*, p. 263.
11. Surface of pileus minutely pubescent or glabrous.
12. Pileus large, woody. *Tr. zimmermannii* 17
12. Pileus small, effused-reflexed to entirely resupinate.
Vide *P. conchatus*, p. 265.
12. Pileus irregularly developed; white patches in context and hymenophore. *Tr. incondita* 18

1. *Trametes cingulata*, Berk.

Pileus thin, annual, coriaceous, rarely reviving, applanate, broadly attached, or somewhat reduced at base, separate pilei at times connate at margin, 3·5 cm. to 9 cm. by 1·6 cm. to 5 cm. by 0·3 cm. to 0·7 cm.; surface black, becoming grey in old specimens, zoned, rough with tubercles or smooth; margin thick and rounded or thin and acute, yellowish brown, velvety to touch; context 1 mm. to 4 mm., soft, corky, fibrous, white to light yellowish, zoned; tubes 1 mm. to 3 mm. long; mouths subrotund, 4 to the mm.; edges entire, white or yellowish to yellowish brown in old specimens, glistening, spores hyaline, globose, 3·7μ to 4μ diam.; hyphae 3μ to 5μ.

Distribution.—A common saprophytic fungus. Recorded by J. D. Keet in Eastern Cape Forest Conservancy on *Acacia* sp.; W. Haygarth, from the Ngoye Forest, Zululand; J. B. Leslie and G. Hobbs, from Howick, Natal; common on stumps and logs of *Acacia mollissima* by the writer.

Easily recognisable by black surface and presence of black spots in old bleached specimens.

2. *Trametes glabrescens* (Berk.), Fr.

Pileus thin, annual, sessile, dimidiate, applanate, 7 cm. to 9 cm. by 4·5 cm. to 5 cm. by 0·2 cm. to 0·6 cm.; surface white becoming discoloured, minutely pubescent, zoned, smooth or rough with tubercles; context white, soft-corky to hard, fibrous, 1 mm. to 4 mm. thick; tubes 1 mm. to 3 mm. long, white within; mouths subrotund to angular, 5 to 6 to the mm.; edges thin, entire, glistening, white changing to yellowish; spores hyaline, globose to elliptical 3·6μ by 5μ; setae none; hyphae 5μ to 7μ diam.

Distribution.—Recorded by J. D. Keet in Eastern Cape Forest Conservancy.

3. *Trametes varians*, n. sp.

Plants effused-reflexed to largely resupinate; pileus corky, rigid, dimidiate, imbricate, at times conchate, 2 cm. to 4 cm. by 0·7 cm. to 2 cm. by 0·5 cm. to 1 cm.; surface azonate, minutely pubescent, frequently somewhat tuberculate, at times rugulose and scabrid, creamy white becoming ochraceous to somewhat fuliginous;

margin acute, cream coloured or fuliginous; context 1 mm. to 2 mm. thick, corky, creamy white; tubes 1·5 mm. long, discoloured within; mouths angular to elongated, irregular, approximating 4 to the mm.; edges entire, creamy white to greyish and greenish drab; hyphae 7·24μ. diam.

Distribution.—Recorded from Eastern Cape Forest Conservancy. (Type in Natal Herbarium, No. 151.)

Differs from *Tr. glabrescens* in habit, surface and pore-characters.

4. *Trametes sycomori*, Henn.

Plants annual, sessile or effused-reflexed; pilei corky, imbricate, connate, 4 cm. to 8 cm. by 3 cm. to 4 cm. by 1 cm. to 2·5 cm.; surface hard, white to creamy, azonate, minutely tomentose and velvety, rugulose; context 0·7 cm. to 2 cm., white, zoned, soft, fibrous, tough; tubes 2 mm. to 6 mm. long, elongated on decurrent portion, white within; mouths subrotund, 2 to 3 to the mm.; edges thick, entire, white to creamy; spores hyaline, smooth, subglobose, 3μ to 4μ; hyphae 4μ to 6μ.

Distribution.—Obtained from the Tugela, Natal, by Indian collector Moonsammy.

5. *Trametes lactinea*, Berk.

Plants annual, sessile or effused reffexed; pileus corky, dimidiate, imbricate, 6 cm. to 7 cm. by 1·5 cm. to 3·5 cm. by 0·5 cm. to 1·7 cm.; surface azonate to indistinctly zoned, decidedly velvety tomentose when young, more minutely pubescent with age, white or ochraceous, rugulose; margin acute or rounded; context white, zoned, 0·5 cm. to 1·6 cm., fibrous, soft, tough; tubes 0·5 mm. to 2 mm. long, white within; mouths subrotund 3 to 4 to the mm., edges entire, thin, white becoming creamy to yellow; spores hyaline, hyphae simple, 4μ to 6μ.

Distribution.—Recorded by E. M. Doidge at Pietermaritzburg, Natal (Herb. Div. Botany, No. 9803); J. D. Keet, in Eastern Cape Forest Conservancy on dry, rotted *Schotia latifolia.*

This plant is close to *Tr. sycomori*, with softer surface, smaller pores, thinner pore wall, and when young more tomentose surface.

6. *Trametes protea*, Berk.

Pileus annual or persisting a second season, coriaceous to corky, dimidiate, decurrent behind or effused reflexed, applanate, conchate, rarely convex below, often laterally extended, frequently very thin and flexible, 1 cm. to 10 cm. by 0·5 cm. to 5·5 cm. by 0·2 cm. to 1·5 cm.; surface smooth, velvety, hispid to villous with soft brown hairs, in old specimens greyish and rough, at times setose, azonate, in thick specimens becoming sulcate; context 1 mm. to 5 mm. corky, fibrous, olive brown; tubes 0·1 mm. to 2 mm. long, paler than context; mouths subrotund to angular or elongated, 2 to 3 to the mm.; edges entire, thin, greyish to fawn or umber spores hyaline, hyphae 3·7μ to 7μ.

Distribution.—A common plant on dead logs and stumps. Found at Pretoria, Transvaal, on fence posts by the writer; at Umfolosi, Zululand, by the writer; at Klapmuts, Cape Province, on stumps of *Populus* sp. and *Pinus* sp. by the writer; in the Ngoye Forest, Zululand, by W. Haygarth.

7. *Trametes violacea*, Lloyd.

Plants annual, sessile, pileus dimidiate, applanate, imbricate, connate, firm and brittle when dry, decurrent, 2·5 cm. to 5·5 cm. by 1·5 cm. to 5·5 cm. by 0·2 cm. to 0·5 cm.; surface corky, firm, purple, zoned, 2 mm. to 3 mm. thick; margin entire; tubes 0·5 mm. to 1·5 mm. long, firm, concolorous with context; mouths circular to angular, 5 to 6 to the mm., edges entire, thin, purple; hyphae 3μ to 6μ.

Distribution.—Saprophytic on logs. Mr. C. G. Lloyd named the plant from specimens collected in Natal by A. T. Janse, and the plant has also been observed around Pietermaritzburg, Natal, by the writer. The plant is close to *Polyporus vinosus*, Berk., but lighter in colour and more brittle.

8. *Trametes griseo-lilacina*, n. sp.

Plants annual, sessile; pileus coriaceous to corky, applanate, imbricate, dimidiate to laterally extended, 3 cm. to 10 cm. by 2·5 cm. to 4 cm. by 4 cm. to 0·8 cm.; surface concentrically sulcate, tomentose to glabrous, fasciculate setose, rugulose, scrupose, grey to greyish fawn; margin acute, tomentose on upper surface; context corky, firm, fibrous, lilac-mauve to mouse coloured, 3 mm. to 4 mm.; tubes 0·5 mm. to 2·5 mm. long, lighter than context; mouths unequal, irregular, round to elongated and angular, 2 to 3 to the mm.; edges thick, entire, concolorous, lilac-mauve; spores hyaline, smooth, oblong, $3{\cdot}7\mu$ by $7{\cdot}5\mu$; hyphae simple, $3{\cdot}5\mu$ to 6μ.

Distribution.—Single collection by Geo. Hobbs on railway sleeper at Illovo River, Natal. (Type in Natal Herbarium, No. 921.)

The context colour and colour of pore mouths is peculiar and should aid in the identification of the fungus. The fungus is evidently related to the Australian *Trametes lilacino-gilva* (Berk), Lloyd, but with rougher surface and irregular pore mouths.

9. *Trametes keetii*, n. sp.

Plants sessile; pileus dimidiate, applanate, woody, firm and rigid, slightly decurrent, 3 cm. to 6 cm. by 2 cm. to 3·5 cm. by 0·4 cm. to 1·5 cm.; surface grey to purplish black, finely tomentose, smooth to scrupose; margin acute to rounded, grey; context 0·2 cm. to 1 cm., hard, rusty brown; tubes firm, 0·2 mm. to 4 mm. concolorous with context; mouths minute, subrotund, 6 to 9 to the mm.; edges entire, thick, firm, concolorous; spores not found, taken to be hyaline, setae present, slender, subulate 21μ to 28μ long; hyphae 4μ to 6μ diam.

Distribution.—A single collection by J. D. Keet in Eastern Cape Forest Conservancy on *Rhus laevigata*. (Type in Natal Herbarium, No. 87.)

10. *Trametes albotexta*, Lloyd.

Pileus sessile, dimidiate, 8 cm. to 10 cm. by 5 cm. by 1·4 cm. to 4 cm.; surface reddish brown, soft to hard, rugulose, tomentose to subglabrous, smooth or scabrid to touch; context 0·4 cm. to 0·7 cm., firm, tough, corky, reddish brown; tubes 0·5 mm. to 1·5 mm. long, tissue white with reddish-brown hymenium; mouths subrotund to angular, 2 to 3 to mm., edges entire or produced into teeth, white changing to yellowish and dark brown; spores pale brown in mass, subglobose 3·7μ by 5μ; hyphae, 4μ to 5μ.

Distribution.—On dead *Podocarpus* sp. in Hlatikulu Forest (Type in Natal Herbarium, No. 181). Collected also by Miss A. V. Duthie.

The surface and context colour are peculiar and would aid in the recognition.

11. *Trametes hispida*, Bagl.

Plants annual, sessile or effused-reflexed; pileus 4 cm. to 10 cm. by 1 cm. to 2 cm. by 0·9 cm. firm, rigid when dry; surface rusty brown, densely hirsute or hispid, azonate, old specimens almost glabrous, soft becoming hard; context reddish brown, soft, spongy above to corky below, becoming firm and woody, 0·5 cm. to 0·7 cm. thick; tubes 1 mm. to 3 mm. long; mouths angular, 2 to the mm.; edges thin, entire, rusty red to greyish brown, spores hyaline; hyphae 4μ to 8μ diam.

Distribution.—Found by J. D. Keet in Eastern Cape Forest Conservancy, saprophytic on *Schotia latifolia*.

12. *Trametes moesta,* Kalch.

Plants sessile, perennial; pileus corky, dimidiate, thickest behind, triangular in section, 3 cm. to 4 cm. by 1·5 cm. to 2 cm. by 0·3 cm. to 1·5 cm.; surface azonate, creamy white to fuliginous, finely tomentose to sub-glabrous, smooth to rugulose; context 2 to 3 mm. thick, fibrous, tough, umber-brown; tubes 1 to 3 mm. long, older filled with hyphae growth, interior white to glaucous; mouths subrotund to elongated and daedaloid, 1 to 2 to the mm. measured transversely; edges entire; spores hyaline; hyphae simple, 2μ to 4μ diam.

Collector.—A. Roberts, locality unknown to the writer.

13. *Trametes subflava*, Lloyd.

Pileus sessile, ungulate, sub-triquetrous, 10 cm. by 14 cm. by 8 cm.; surface soft, velvety-tomentose, light yellow; context 0·5 cm. to 2 cm. thick, yellow, soft, tough, towlike; tubes 1 mm. or less long; mouths subrotund 4 to 6 to the mm.; edges thin, entire, darker yellow than context, shining; spores hyaline, globose, 4μ diam.

Distribution.—Found on live *Celtis kraussiana* by J. D. Keet in Eastern Cape Forest Conservancy. (Cotype in Natal Herbarium, No. 388.)

The entire plant is concolorous except that the pores are a darker yellow. The surface and context are a light maize yellow.

14. *Trametes obstinatus*, Cke.

Plants woody, perennial, sessile, to effused-reflexed or decurrent behind; pileus large, dimidiate, imbricate, 7 cm. to 30 cm. by 4 cm. to 12cm. by 4 cm. to 4·5 cm. applanate, at times concave above; surface yellowish buff, grey or brown, velvety tomentose becoming subglabrous when old, often tuberculate, azonate or zoned, at times concentrically sulcate, frequently somewhat rimose with age; context creamy white to yellowish buff, 2 cm. to 3·5 cm., zoned or azonate, fibrous, hard and woody, shining; tubes 0·5 mm. to 2 mm. long, white to yellowish, older layers indistinct and blocked up; mouths 1 to 4 to the mm., subrotund to elongated becoming sinous and daedaloid, white to yellow; spores not found; hyphae, 5μ to 7·5μ, simple.

Distribution.—A common fungus. Found by the writer on live *Acacia mollissima* and on live *Citrus* trees, around Pretoria; around Durban, Natal, on undetermined hosts; in the Ngoye Forest, Zululand, by W. Haygarth; in Eastern Cape Forest Conservancy on *Celtis kraussiana* by J. D. Keet.

15. *Trametes tomentosa*, n. sp.

Plants effused-reflexed, annual; pileus applanate, coriaceous 9 cm. by 7 cm. by 0·1 cm. to 0·4 cm.; surface with a few faint furrows, rugulose, covered with a soft cinnamon brown tomentum; margin thin, undulate; context 0·5 mm. to 2 mm. thick, azonate, corky, shining, straw yellow; tubes 0·5 mm. to 1·5 mm. long, elongated on decurrent part, concolorous with context; mouths subrotund to irregular, 2 to 3 to the mm.; edges thick towards margin, thin in older parts, entire to somewhat lacerate, yellow-buff; hyphae 4μ to 5μ diam.

Distribution.—Found on dead logs at Durban, Natal, by the writer.

The plant is in its context colour and colour of pore mouths close to *P. occidentalis*, Kl., from which it differs in the finer tomentum. The hairs are longer and finer and the surface has a feeling of plush. (Type in Natal Herbarium, P. v. d. B., No. 836.)

16. *Trametes ochrolignea*, Lloyd.

Plant forms a hard flat, woody and unseparable mass, 2 mm. thick, on the wood on which it grows, the periphery of this mass is continued into the pilei or the pilei develop separately from it; pilei subcircular 6 cm. to 10 cm. diam. by 0·7 cm. to 2 cm. thick; surface uneven, tuberculate, reddish brown, more yellow towards margin, tomentose, with a few concentric furrows; context 3 mm. to 9 mm. thick, corky to hard and woody, yellow, shining; tubes

about 1 mm. long; mouths round to elongated, irregular, 2 to 3 to the mm.; edges thick or thin, somewhat lacerate, yellow; spores hyaline, smooth, $3{\cdot}7\mu$ by 7μ; hyphae 3μ to 7μ diam.

Distribution.—Found at Durban, Natal, on rotten log. Distinguished from *P. occidentalis* by its habit of growth, more tuberculate surface and context in older part and part above substratum being extremely hard and woody. (Cotype in Natal Herbarium, No. 226.)

17. *Trametes zimmermannii*, Bres.

Plants perennial, sessile; pileus dimidiate, convex, woody, 8 cm. by 4·5 cm. by 1 cm. to 3 cm., decurrent behind; surface hard, ashy grey, azonate, minutely tomentose to glabrous, somewhat fissured but not rimose; context straw yellow, hard and woody, zoned, shining; tubes 1 mm. or less long, elongated on reflexed portion, stuffed in older strata; mouths subrotund to irregular, approximately 2 to 3 to the mm.; edges entire, firm.

Distribution.—Found at Pietermaritzburg, Natal, by the writer. According to Mr. C. G. Lloyd this fungus was named as above by Bresadola in MSS.

18. *Trametes incondita*, Fries.

Plants sessile or resupinate, pilei perennial, corky or woody, irregularly developed, at times imbricate, 3·7 cm. to 7·5 cm. by 2 cm. to 3·5 cm. by 0·3 cm. to 2 cm.; surface closely concentrically sulcate, dark; context thin, corky, yellow, with white corky patches and this white tissue appears to practically replace the true context; tubes 0·4 mm. long, yellow within, becoming stuffed in older layers, areas of white patches also in hymenophore in section; mouths subrotund, 4 to the mm., edges thin, entire, yellow; spores irregular globose to elliptic, 7μ to 8μ diam. to 5μ by 7μ to 8μ; hyphae 2μ to 4μ.

Distribution.—Recorded by J. D. Keet in Eastern Cape Forest Conservancy on *Ptaeroxylon utile*.

Recognisable by the irregular development of the pilei, the short tubes and the white patches in the attacked wood, in the context and between the tubes in section.

A study on the development of this fungus should prove interesting. On attacked wood there are small, pale, corky nodules, white within, which are evidently the beginning of the development of pilei. In the irregular pilei these nodules are evident at the back and the pilei are by them evidently attached to the substratum. These nodules also develop from the back of the pilei.

Daedalia (Pers.), Fr.

Plants sessile or effused reflexed, epixylous, annual, rarely reviving; pileus coriaceous to tough, corky or somewhat woody; context white to light coloured, tough, firm, corky or subwoody; hymenophore typically daedaloid, but sometimes poroid or lamellate; spores hyaline.

This genus differs from *Trametes* only in the hymenial surface. The pore walls is some of the *Daedalia* spp. are often as strongly lamellate as in *Lenzites*.

KEY TO THE SPECIES.

Context brown. Vide *Tr. moesta*, p. 284.
Context white or light coloured.
Pileus corky to woody, surface velvety with a grey or brown tomentum. Vide *Tr. obstinatus*, p. 285.
Pileus white, coriaceous to corky, finely tomentose, context shining and shade of colour varying with angle of light. *D. Hobbsii* 1

1. *Daedalia Hobbsii*, n. sp.

Plants annual, sessile; pileus dimidiate, coriaceous to corky, imbricate, laterally connate, decurrent at attachment, 5 cm. to 12 cm. by 4 cm. to 5 cm. by 0·5 cm. to 2 cm.; surface white, finely tomentose to subglabrous, azonate, usually tuberculate, rarely smooth; context 0·4 cm. to 1·4 cm. fibrous, tough, soft when fresh, drying firm and corky, zoned, wood-coloured, shining, shade varying with angle of light; tubes 2 to 5 mm. long, elongated on decurrent portion, white within; mouths poroid and subrotund to elongated and daedaloid, 2 to 3 to the mm. measured transversely; edges thick, entire white; spores hyaline, smooth, globose, 3μ to 4μ diam.; hyphae simple 3μ to 5μ diam.

Distribution.—Found at Howick, Natal, by G. Hobbs. (Type in Natal Herbarium, No. 922.)

The context has a satiny lustre when smoothly cut and the shade of colour appears different according to the angle of the light.

Lenzites, Fries.

Plants epixylous, annual, sessile (in *L. repanda* usually substipitate) or effused reflexed; pileus coriaceous to corky and firm and rigid; context white or brown, coriaceous, corky, tough; hymenophore typically lamellate, more rarely (e.g., *L. trabea*) daedaloid or poroid; spores hyaline; crystida absent or present.

KEY TO THE SPECIES.

1. Context brown. *L. trabea* 1
1. Context white.
   2. Surface and entire plant white, not tomentose. *L. repanda* 2
   2. Surface tomentose, greyish to brown or reddish brown.
   3. Surface velvety tomentose, closely zoned, usually greyish; edges of lamellae entire; margin thin. *L. betulina* 3
   3. Surface velvety tomentose to rough, greyish brown to reddish brown, edges of lamellae becoming much dentate; margin thick. *L. aspera* 4

1. *Lenzites trabea*, Otth.

Plants annual, sessile, pileus dimidiate to laterally expanded, at times imbricate, 1 cm. to 10 cm. by 1 cm. to 3·5 cm. by 0·1 cm. to 0·6 cm., coriaceous to corky; surface cinnamon brown to greyish-brown, corky, glabrous, to subtomentose, smooth to rugulose, zoned or azonate, context cinnamon-brown to snuff-brown, fibrous, corky, 1 mm. to 4 mm. thick; hymenophore poroid to labyrinthiform, rarely entirely lamellate; pores or lamellae 1 mm. to 4 mm. deep, in poroid forms the pores are irregularly angular and in lamellate the lamellae freely anastomose; mouths 2 to 3 to the mm., concolorous with surface, edges thin, entire; spores smooth hyaline, ellipsoid, 7μ to 8μ by 4μ to 7μ diam.

Distribution.—Common on stumps and logs of *Pinus* and *Populus* in Western Cape Province by the writer.

2. *Lenzites repanda* (Pers), Fries.

Pileus substipitate, circular to flabelliform or reniform, frequently large, 2 cm. to 32 cm. diam. by 0·1 cm. to 1 cm. thick, tough, coriaceous to somewhat firm and rigid; surface azonate to zoned, pure white when fresh, glabrous, smooth or tuberculate, margin entire to undulate and rarely lobed; context 1 mm. to 3 mm., white to cream coloured, floccose, fibrous, corky, zoned; hymenophore poroid to daedaloid and lamellate, lamellae 0·5 mm. apart, 1 mm. to 4 mm. deep, coriaceous firm, branched and anastomosing, edges white to discoloured; spores hyaline, oblong or suballantoid, 5μ to $8{\cdot}5\mu$ by 2μ to 3μ; hyphae hyaline, branched, 4μ to $5{\cdot}6\mu$ diam.

Distribution.—Common on dead logs and stumps. Recorded by W. Haygarth from the Ngoye Forest, Zululand; Miss A. V. Duthie, from Knysna, Cape; J. D. Keet, Eastern Cape Forest Conservancy; common on *Acacia mollissima* stumps and logs in midlands of Natal by the writer; Howick, Natal, by Geo. Hobbs.

Daedalia elegans, Spreng., *Trametes elegans*, Fr., are really the same fungus and the older name, *Lenzites applanata* (Klotz) ex Fries is also held to be synonymous; *Lenzites Palisoti*, Fr., is usually also held to be synonymous, but I have not seen specimens so referred. There are other synonyms for this common fungus.

3. *Lenzites betulina* (Linn), Fr.

Plants annual, sessile; pileus, dimidiate to flabelliform, imbricate, coriaceous to corky, 1·5 cm. to 9 cm. by 1 cm. to 6 cm. by 0·3 cm. to 1 cm.; surface tomentose marked with concentric zones, prevailing colour greyish, and in one collection a red zone was present; faintly furrowed to plicate; context 0·4 mm. to 2 mm., white, coriaceous, azonate; hymenophore lamellate, rarely poroid, lamellae coriaceous, white to cream; edges entire, undulating; spores hyaline, oblong, 4μ to 6μ by 2μ to $2{\cdot}5\mu$; cystidia hyaline, sharp-pointed.

Distribution.—A widespread and common saprophyte on dead logs and stumps. Recorded by J. D. Keet on dead *Olea laurifolia*

and *Acacia mollissima* in Eastern Cape Forest Conservancy; T. J. van de Merwe, on live *Celtis kraussiana* in Eastern Cape Forest Conservancy; J. D. Keet, on *Pinus* sp. and dead logs at Knysna, Cape; the writer at Nottingham Road, Natal Province; frequent on *Acacia mollissima* logs in plantations in Natal.

Lenzites flaccida, Fries., is taken to be synonymous with the above, and the same is the case with *Lenzites quineensis*, Fr. According to type idea, *L. betulina* is thick and suberose and *L. flaccida* thin and flaccid, but both are, I think, really one and the same fungus. *L. quineensis* has firmer and more rigid lamellae than *L. betulina*, and this appears to be the only difference.

4. *Lenzites aspera*, Klotzsch.

Plants annual, sessile, pileus dimidiate, applanate, conchate, imbricate, coriaceous-corky, 7 cm. to 10 cm. by 3 cm. to 7 cm. by 0·2 cm. to 1 cm.; surface concentrically sulcate, covered with a greyish brown to reddish-brown tomentum which varies from velvety to rough; margin thick, rounded, buff-coloured, velvety; context 1 mm. to 7 mm. thick, fibrous, corky, white, zoned; hymenophore daedaloid to lamellate, lamellae 2 mm. to 6 mm. deep, coriaceous, edges becoming much dentate; hyphae hyaline, simple, 4μ to 7μ diam.

Distribution.—On *Eucalyptus globulus* at Elgin, Cape Province. (Herb. Div. Bot., No. 7075.) Recognised by the greyish to reddish-brown tomentum and dentate lamellae. The colour of the surface is darker than in *L. betulina* and the pileus as a whole thicker and firmer than in that species, from which it is also distinguished by the thick round margin and the dentate lamellae.

Hexagona, Fries.

Plants epixylous, sessile; pileus coriaceous to corky or hard and woody; ungulate or applanate, in some very thin (e.g., *H. tenuis*); surface azonate, zonate or sulcate, glabrous to velutinate or setose; context corky to woody, rarely fleshy, usually coloured, in a few white or pale, for example *H. albida;* pores usually large, subrotund to hexagonal. In *H. tenuis* and allied species the pores are smaller than usual and shallow, in these small-pored Hexagonas the pores are regular.* In some of the species with white or pale context, daedaloid and lenzitoid forms occur together with the normal hexagonal forms; setae absent or present, coloured; spores hyaline.

KEY TO THE SPECIES

1. Tubes shallow, mouths small, 0·5 mm. to 1 mm. diam.		
2. Context reddish-brown.	*H. tenuis*	1
2. Context light to fawn.	*H. rigida*	2
1: Tubes deep, mouths large, 2 to 4 to the cm.		
3. Context reddish brown.		
4. Setae absent.	*H. speciosa*	3
4. Setae present.	*H. pobeguini*	4

* The regular pores would distinguish these species from *Polyporus spp.* (for example e.g. *P. pinsitus*) with shallow and as large pores, but differing in that they are irregular.

1. *Hexagona tenuis* (Hk.) Fries.

Pileus thin, sessile or effused reflexed, coriaceous, flexible, dimidiate to conchate, or flabelliform, applanate 3·5 cm. to 7 cm. by 2 cm. to 4·5 cm. by 0·05 cm. to 0·2 cm., often narrowly attached and laterally connate; surface glabrous, concentrically zoned, umber brown, smooth to rugulose, margin thin, entire to undulate and rarely lobed; context rusty brown, tubes 0·5 mm. to 1 mm. long, pale greyish green within; mouths hexagonal 0·5 mm. to 1 mm. in diam.; edges thick, firm, entire, dark brown; spores not found; hyphae 4μ diam.

Distribution.—A widely distributed and common saprophyte. Recorded by W. Haygarth from Ngoye Forest, Zululand; on dead branches of *Hibiscus tiliaceus*, *Xanthoxylon capense*, and *Albizzia fastigiata* around Durban, by the writer; Barberton, Transvaal, by Geo. Thorncroft.

Hexagona polygramma, Mont ex. Fr., is too close to above to be regarded as a distinct species. The pores according to the type idea are somewhat larger but no larger than is found in one and the same collection of *H. tenuis.* It is not even good as a variety.

In specimens around Durban there was frequently noticed a reddish-black stain at the base of the pileus or even extending some distance over the pileus. These specimens were referred to *Hexagona tricolor*, Fries. (or *Hexagona discopoda*, Pat. and *H. umbrinella*, Fr.). This stain was absent and present on specimens of one and the same collection and would under the circumstances not be considered as constituting a specific difference. The specific names may be used to convey conditions of *H. tenuis*, but no more.

2. *Hexagona rigida*, Berk.

Pileus sessile or effused reflexed, thin and coriaceous to thicker and more firm, applanate, dimidiate to conchate or flabelliform, often laterally extended and connate, 3·2 cm. to 7 cm. by 1·8 cm. to 4 cm. by 0·1 cm. to 1 cm.; surface concentrically zoned to slightly furrowed, pale-wood coloured to fawn, smooth or rugulose; margin thick or thin, entire to undulate; context 0·05 mm. to 9 mm., fibrous, corky, white to lightly coloured; tubes 2 mm. or less long, white to fawn within, mouths circular to hexagonal, 0·5 mm. to 1 mm. in diam.; edges thick, white to yellow or fawn; hyphae 4μ to $5{\cdot}5\mu$.

Distribution.—Not uncommon around Durban, by the writer, and varying considerably in thickness. Some collections also had the reddish-brown stain mentioned under *H. tenuis.*

The plant differs from *H. tenuis* by lighter colour of context.

A specimen collected at Victoria Falls by Miss A. V. Duthie, of the University of Stellenbosch, and referred to *Hexagona phaephora*, Pat., differs from above in somewhat darker pores, but no more than one finds in collections of *H. rigida*, and is referred here.

3. *Hexagona speciosa*, Fr.

Pileus sessile, woody, firm and rigid, dimidiate, applanate, conchate or cupshaped, at times somewhat decurrent behind, 8 cm. to 18 cm. by 5 cm. to 12 cm. by 0·6 cm. to 4 cm., thickest behind, narrowly attached; surface with a thin crust zoned to slightly furrowed, fawn coloured, smooth to tuberculate, margin thick or thin, undulate; context 0·2 cm. to 1·5 cm. thick, reddish-brown, firm, corky, to subligneous; tubes 4 mm. to 12 mm. long, concolorous with context or glaucous within, mouths subcircular to hexagonal, 3 mm. to 4 mm. diam.; edges thick or thin, at times lacerate; fawn to reddish-brown; setae absent; hyphae $3{\cdot}7\mu$ to $7{\cdot}4\mu$ diam.

Distribution.—Found around Durban, Natal, by the writer, and in the Ngoye Forest, Zululand, by W. Haygarth; from Rhodesia by C. Swynnerton. The zones are at times coloured reddish-brown.

4. *Hexagona pobeguini*, Hariot.

Pileus dimidiate, applanate, woody, 12 cm. to 20 cm. by 7 cm. to 13 cm. by 0·5 cm. to 2·5 cm., surface grey to brown, minutely pubescent, becoming glabrous or scabrid with age and frequently somewhat cracked, concentrically zoned and sulcate, the zones at times different shades of brown; margin thick or thin, undulate; context 2 mm. to 4 mm. thick, reddish-brown, corky, firm; tubes 0·3 cm. to 2 cm. long, concolorous with context; mouths 2 to 3 to the cm., subrotund to hexagonal, irregular; edges firm, reddish-brown, velutinate; setae present and very prominent.

Distribution.—In the Woodbush, Zoutpansberg (Herb. Division Botany, 1317 and 1319).

Distinguishable from *H. speciosa* by the presence of setae.

Favolus, Fries.

Plants epixylous, annual; pileus more or less laterally stipitate, fleshy-tough when fresh; context white, pores angular or hexagonal, radially elongated; stipe lateral; spores white; setae absent or present (*F. megaloporus*).

KEY TO THE SPECIES.

1. Setae present.
   Setae in hymenium aculeate and with aculeate spines. *F. megaloporus* 1
1. Setae absent.
   Tubes up to 3 mm. long; mouths 3 mm. to 5 mm. by 0·8 mm. to 1 mm. *F. brasiliensis* 2

1. *Favolus megaloporus* (Mont), Bres.

Plants annual, laterally stipitate; pileus coriaceous, applanate, spathulate or flabelliform, 1·5 mm. to 5 mm. by 1·5 mm. to 3·5 mm. by 0·4 mm.; surface white to reddish brown, glabrous, striate; margin thin, incurved in drying; context 0·8 mm. to 2 mm. white

to discoloured, soft, tough; tubes 2 mm. to 3 mm. long, decurrent on stipe; mouths angular, radially elongated, 1 mm. to 2 mm. by 0·5 mm.; edges thin, ultimately becoming split into irregular teeth; spores (teste Bresadola) hyaline, oblong, 9μ to 12μ by 4μ to 5μ; setae present, coloured, aculeate and with aculeate spines.

Distribution.—Found at Durban on log, by the writer. Easily recognised by the coloured, spiny setae in the hymenium.

In addition to the species named, *Favolus dermoporus* (Pers), Lloyd, *Favolus europaeus*, Fr., and *Favolus spathulatus* (Jungh), Bres., have been collected by the writer, but the material of these has been very scanty. Medley Wood has further recorded *Favolus rhipidium*, Berk., from Natal.

2. *Favolus brasiliensis*, Fries.

Pileus stalked, thin, applanate, coriaceous, spathulate, flabelliform or reniform, 2 cm. to 7 cm. by 1·5 cm. to 5 cm. by 0·1 cm. to 0·4 cm.; surface white, radially striate, minutely pubescent to glabrous; margin thin, undulate to lobed and fissured with age; context thin, up to 1 mm. white, soft; tubes 1 mm. to 3 mm. long, decurrent on stalk, mouths 4 to 6-angled, elongated radially, 2 mm. to 5 mm. by 0·8 mm. to 1 mm.; edges white changing to yellowish, thin, splitting into irregular teeth; spores hyaline, smooth; setae absent; hyphae 2μ to 4μ; stalk lateral 0·5 cm. to 2·5 cm. long by 3 mm. to 5 mm. diam; somewhat dilated at attachment, finely tomentose.

Distribution.—Found around Durban by the writer, common on dead logs.

Favolus jacobaeus, Sacc. (*Polyporus favoloides*, Henn) is close to above and differs in somewhat smaller pores. It is probably best held as a small-pored form of it. In some collections of this small pored form the surface was somewhat tessellate, and these tended to connect this species with *Favolus tessellatus*, Mont. *Favolus freisii*, Berk and Curt., is a thin white species, but specimens so far seen of it have been very scanty. It, however, appears to be too close to above. Specimens preserved by J. Medley Wood (No. 99) under the name *P. vibecinus*, Fr., are evidently also referable to the small pored form.

Laschia, Mont.

Small annual gelatinous pore-fungi, centrally or laterally stipitate or sessile. Surface most frequently tessellate. Majority coloured (a few white). Colour contained either in ordinary cuticular cells, in stalked gland-like bodies, or in long cylindrical colour cells.* In addition, some have hyaline cristated cells which may be either oval and crowned with spiny processes or of the nature of long cylindrical cells covered with spiny processes. Pores angular, honeycombed, usually shallow. Spores hyaline.

* This appears to have been first investigated by Mr. C. G. Lloyd.

KEY TO THE SPECIES.

Colour gland and cristated cells both absent.

Plant laterally stipitate, orange red, exceeding 2 mm. in diam.
L. Thwaitesii 1

1. *Laschia Thwaitesii*, B. and Br.

Pileus laterally stipitate, reniform, 3 mm. to 5 mm. in diam., 0·5 mm. thick, orange red, surface strongly tessellate; colour glands and cristated cells absent, cuticular cells with coloured contents; pores hexagonal 3 to 4 to the mm., row adjoining stalk radially elongated; stipe 1 mm. to 2 mm. long, 0·3 mm. to 0·5 mm. diam, concolorous with pileus.

Distribution.—Not uncommon in bush around Durban on dead branches lying on the ground, found by the writer. Usually it grows caespitose. The specimens collected were all rather small. Other *Laschia* spp. have been recorded, but so far have not come to the writer's notice.

ADDENDUM: NOTE ON AN INTERESTING ABNORMAL FORM OF POLYPORUS LUCIDUS, LEYSS.

Read July 12, 1921.

In a previous publication of this JOURNAL* we have dealt with the fungus *Polyporus lucidus*, and illustrated the fructifications very fully. An abnormal form of the fungus (*P. lucidus*) was collected by Mr. A. L. Forbes on a log of wood in a mine at Johannesburg between 4,000 to 5,000 feet below the surface. Two specimens were found. Other fungi, and notably *Lentinus lepideus*, are known often to take on very peculiar and almost unrecognisable forms when growing in mines, and this abnormality in *Polyporus lucidus* is of great interest.

The tall specimen of *P. lucidus* measured 2 feet 7 inches in height and was entirely sterile, whereas the other specimen had the two larger branches fertile at the top for a length of about 5½ inches.

---

* *South African Journal of Science*, Vol. XIII, pp. 506-515.

BRYOPHYTA OF SOUTHERN RHODESIA.

BY

T. R. SIM, D.Sc., F.L.S., and H. N. DIXON, M.A., F.L.S.

Read July 15, 1921.

The present paper dealing with the Bryophyta, mainly of Southern Rhodesia, consists of three portions. The introductory section has been prepared by the first-named author, who also deals with the second section on the Hepaticae, while the third section, relating to the Mosses, has been the work of the second-named author.

CONTENTS. Page

I.—CONDITIONS AFFECTING THE DISTRIBUTION OF BRYOPHYTA IN RHODESIA.

BY

T. R. SIM, D.Sc., F.L.S.

Such a huge area as Rhodesia would naturally be expected to have a very considerable moss flora, but so far very few species have been recorded. This is partly through its being as yet bryologically unexplored, but much more completely through its natural conditions.

The greater part of Rhodesia is in a general way a flat plateau, 3,000 to 5,000 feet altitude, with a few higher granite ridges scattered in. These conditions favour mist-laden clouds passing overhead, without depositing rain or dew, and consequently the general atmospheric condition is one of aridity, which becomes more and more pronounced westward, where Rhodesia meets the still drier Kalahari desert in Bechuanaland, and where the aridity may have increased considerably during recent decades through the drying up of the lake district whence its clouds mostly come.

It is the presence of that dry region, and of the flat arid surface, which leads to rains being few but torrential; mists usually absent, vegetation a scattered and xerophytic scrub intermixed with grass, while Bryophyta are almost absent from all western localities, and of comparatively few species even in the east, though what species there are become much more abundant eastward, especially on the escarpment and on the hills and valleys overlooking the sea slope and the Limpopo and Zambesi valleys, where mists are frequent and conditions much more congenial.

During my recent tour I found mosses almost absent west of 32° East, except at the Falls of the Zambesi, but from there

eastwards as at Mazoe, Umtali, Melsetter, Zimbabwe, etc., conditions approach much more nearly to those of the Drakensberg further south, and in a few localities regular forest conditions occur, bringing with them mosses in abundance.

Even at Zimbabwe, which is quite in the mist-belt and bushveld, though not in the forest range, mosses are in great abundance, though belonging to few species. One naturally enquires why few species, and it would appear that the dry winter, the granite formation and the strong sunshine, combine to make the conditions sufficiently arid during the winter to kill out such species as are not extremely tenacious of life.

The Zimbabwe rocks and ruins are wonderfully moss-clad, as also are the rocky kopjes in that region, but it is noticed there that such species that can endure on bare rock, or on soil in rocky crevices, are those which flourish, and that these exhibit very marked pioneer qualities, particularly notable in *Aongstroemia gymnomitrioides* Dixon, and in Campylopus.

In regard to the Zambesi Falls, where the rain forest and the spray-steeped cliffs would lead one to expect mosses in abundance, it is the case that a few species are there in profusion in certain places; a hundred yards away from the gorge in any direction one is again in the arid plateau, mostly sandy, and devoid of all moss vegetation.

Trees are frequent, mostly of a xerophyllous nature, but no epiphytic mosses occur on them outside the rain forest. The Zambesi has travelled through hundreds of miles of arid country since it left its mid-African forest sources, and the same aridity exists in all directions. Consequently what species occur at the falls are rather a survival of the most enduring, than a full representation of tropical forest moss-flora. The perpendicular and inaccessible cliffs overlooking the falls just beyond the spray limit are thinly clad with succulents but not with mosses, while away from the falls, down the river and where spray is absent, the Zambesi gorge is a deep chasm, where succulents and xerophytes exist and flourish rather than a suitable locality for any other than the most hardy mosses. Up the river, above the falls, the variations of water level render rocks and banks submerged for months and then dried out for other months, and so are almost without mosses.

One hundred and twenty-nine species of mosses, and twenty-four of Hepaticae are now recorded from Southern Rhodesia, of which over eighty mosses and all the Hepaticae were collected during the visit of the South African Association for the Advancement of Science last year—mostly at the Victoria Falls or at Zimbabwe.

Twenty-three of these mosses are new to science and are described hereunder by Mr. Dixon, seven others were previously described by Mr. Dixon from Rhodesia as new to science, so altogether Rhodesia has provided recently thirty new species of Musci out of its small total.

The Hepaticae are all previously known from elsewhere.

The relationship of the Zimbabwe and eastern mosses is almost entirely with species found further south; the relationship of those found at the Victoria Falls is only to a very small extent with the mid-African flora, probably accounted for by the long distance of arid country by which that site is separated from other suitable localities northward. Even trees seem to have travelled along the Zambesi from mid and western Africa more easily than Bryophyta.

The endemic species are mostly from the Victoria Falls.

Aongstroemia gymnomitrioides Dixon is a most interesting pioneer on bare flat rocks, abundant at Zimbabwe, present elsewhere, and closely related to a Natal Drakensberg alpine species, both being closely related to a far South American mountain species, and very distinct as a group from all other mosses.

The western part of Rhodesia will probably not yield many more mosses until more closely settled, but the eastern part, particularly Umtali and Melsetter, is furnished with forest areas where forest mosses may be expected to exist in abundance, but which bryological collectors have still hardly touched. These parts of the escarpment, together with its eastern face in Portuguese East Africa, for a bryological *terra incognita* from which a rich harvest may be expected when their close investigation is undertaken. Below these the Portuguese flats are arid and almost without mosses; even where trees abound along the river banks the subsoil is moist, but the atmosphere is very arid.

II.—HEPATICAE.

BY

T. R. Sim, D.Sc., F.L.S.

Riccia fluitans, Linn. "Spec. Plant." p. 1606.

This belongs to section Ricciella, sometimes treated as a distinct genus.

Zimbabwe, 3,000 feet, Sim 9065; Khami Stream, Sim, 9067; Victoria Falls Rain Forest, Sim, 9066; Matopos, Miss Gibbs, 318. Usually found floating in water or set in mud.

General distribution: Frequent in all sub-tropical countries.

Riccia albomarginata, Bisch. "Syn. Hep." 604.

Matopos, 5,000 feet; Sim, 9068; Stream at Bulawayo, 5,000 feet, Sim, 9069; Zimbabwe, 3,000 feet, Sim, 9070, 9071, 9072; Rhodes' Grave, Matopos, 5,000 feet, Sim, 9073.

General distribution: Tropical and sub-tropical South Africa.

Targionia hyophylla, Linn. "Spec. Plant," p. 1,604.

Matopos, near Hotel: 5,000 feet, Sim, 9080.

General distribution: Africa, Southern Europe, South America and Australia.

Plagiochasma rupestre, St. "Spec. Plant." p. 783.

Matopos, Eyles, 937 and 1181; Zimbabwe, Sim, 9081.

General distribution: Mediterranean and Africa.

Grimaldia capensis, St. "Spec. Hepat." p. 793.

Rhodes' Grave, Sim, 9077; Zimbabwe acropolis, Sim, 9074 and 9079; Matopos, 5,000 feet, Sim, 9075 and 9078; Mazoe, Eyles, 606; Victoria Falls, Sim, 9076.

General distribution: South Africa.

Fimbriaria marginata, Nees in "Hor. Phys. Berol.," 1820, p. 44.

Matopos, 5,000 feet, Eyles, 932 and 933.

General distribution: South Africa—common.

Fimbriaria wilmsii, St. Hedwigia, 1892, p. 122.

Makoni, 4,700 feet, Eyles, 786.

General distribution: South Africa.

Marchantia wilmsii, St. Hedwigia, 1892, p. 126.

Mazoe, Tatagura River, 4,300 feet, Eyles, 708; Victoria Falls, 3,000 feet, Sim, 9082.

General distribution: South Africa.

Aneura pinnatifida, Dum.

Victoria Falls, 1910, Miss Farquhar, 23; Sim, 9083.

General distribution: Each continent.

Metzgeria furcata, (L.) Lindb. "Monog. Metzg." p. 35.

Zimbabwe, Sim, 9083.

General distribution: Africa, Australia, South America.

Fossombronia pusilla (Linn.) Dum.

Matopos, 4,600 feet, Mch. 1916, Eyles, 936.

General distribution: Europe, North America, Africa.

Frullania diptera, Nees.

Mazoe, 4,300 feet, 1917, Eyles, 715; many localities (Sim).

General distribution: South Africa.

Frullania squarrosa, L. and G.

Zimbabwe, 3,000 feet, Sim, 9084, 9085; Victoria Falls, 3,000 feet, Sim, 9086; Matopos, 5,000 feet, Sim, 9087.

General distribution: Europe, Africa.

Frullania trinervis, L. and G.

Umtali, 5,000 feet, Eyles, 1724.

General distribution: Europe and Africa.

Lejeunea cavifolia (Ehrh.), Lind.

Inyanga, 6,000 feet, Eyles, 1363; Mazoe, Eyles, 713a and 714; Zimbabwe acropolis, Sim, 9093; Victoria Falls, Sim, 9092.

General distribution: Very wide in sub-tropical climes.

Lejeunea, (*Mastigolejeuna*) sp.

Palm Grove, Victoria Falls, 2,500 feet, Sim, 9094.

Olive green, loosely tufted on stones, but material collected was insufficient for identification or description.

Ptycholejeunea striata, L. and L.
Umtali, Eyles, 1733; Victoria Falls, Sim, 9095.
General distribution: Tropical and sub-tropical Africa and Asia.

Madotheca capensis, Gottsche.
Umtali, 4,200 feet, 1919, Eyles, 1733; Chirinda, 3,800 feet, Swynnerton, 812.
General distribution: South Africa.

Radula capensis St.
Victoria Falls, Sim, 9089; Palm Grove, Sim, 9088; Zimbabwe, Sim, 9090; Matopos, 5,000 feet, Sim, 9091.
General distribution: South Africa.

Cephalozia divaricata Spr.
Zimbabwe rocks, mixed in Campylopus, Sim, 9096.
General distribution: Very wide.

Plagiochila crispulo—caudata, Gottche.
Zimbabwe, 3,000 feet, Sim, 8577 and 9098; Khami Ruins, 5,000 feet, Sim, 9097; Umtali, 5,000 feet, Eyles, 1721; Matopos, 5,000 feet, Sim, 9099.
General distribution: Africa and African Islands.

Calypogeia bidentula, Nees.
Scraps of this were found among mosses sent by Miss Duthie from island in the Zambesi, above the Victoria Falls, September, 1916.

Anthoceros punctatus Linn.
Under running water—Makoni, 4,700 feet, Eyles, 785 and 790; Rain Forest, Victoria Falls, Sim, 9100; Zimbabwe, Sim, 9101.

Anthoceros crispulus Douin.
Rain Forest, Victoria Falls, Sim, 9102, and Miss Duthie, September, 1916.

III.—A CONTRIBUTION TO THE MOSS FLORA OF SOUTHERN RHODESIA AND PORTUGUESE GAZA-LAND.

BY

H. N. DIXON, M.A., F.L.S.

The following list of mosses from Southern Rhodesia breaks almost entirely new ground. So far as I am aware the only published references to the bryological flora of the district are contained—apart from one or two scattered records of individual species—in a paper by Mr. F. Eyles, "Records of Plants collected in Southern Rhodesia" (Trans. Roy. Soc. of South Africa, Vol. V, Pt. 4, May, 1916), where he mentions eight species of Mosses

and five of Hepaticae. A few localities are given by Brotherus in a report of mosses collected by Brunnthaler in various parts of South Africa in 1909 (2).

The present list is principally drawn up from collections made by Dr. Sim at various times, but especially in the course of an extensive tour through the district in 1920, during which the Zimbabwe Ruins, Khami Ruins, Matopos and Victoria Falls were visited, and good collections made throughout. About the same time Prof. Wager visited the district, covering the same ground to a great extent, and his collections were sent to me for determination. Mr. Eyles has collected mosses from time to time, a good many of which have passed through my hands from the British Museum, and from Dr. Sim, who has also sent me a few collected by Mr. Teague around Umtali. A few of Mr. Eyles' plants were collected by Dr. Nobbs and Mr. J. H. Henkel.

The number of species listed below—about 125—is not large, and is without doubt capable of extension. At the same time, I think it probable that the present list furnishes a much higher percentage of the actual moss flora than would be expected in the case of most areas of so large extent, and at the same time so very slightly explored. This conclusion is based partly on the general phytogeographical conditions of Southern Rhodesia, for data as to which I am indebted to Dr. Sim. From these data—detailed by Dr. Sim in the introduction to this paper—it is clear that the district generally speaking is a xerophytic one, extremely so in the western parts, less so, but still decidedly of that character in the eastern. In these parts where Dr. Sim's collections were mostly made, the percentage of species is obviously low as compared with the number of individuals; mosses appear in fair quantity but of comparatively few species, and definitely xerophytic in character.

The one part of the district where one would expect a possibly rich moss flora is that of the Zambesi Valley round the Victoria Falls. The conditions of humidity and of temperature would predispose one to expect something of the bryophytic flora of the tropical rain-forest. The moss flora is, indeed, much richer there in individuals, and their character is widely different from those of the arid veld; but the number of species is somewhat disappointing, and the relationship to the tropical moss flora is very slightly marked. This, however, as Dr. Sim points out, is quite explicable when one considers the isolated position of the area in question. The actual part of the gorge which is kept moist by the spray of the Falls is very limited, and a hundred yards away from it, in any direction, takes us into the arid plateau. That xerophytic conditions prevail even so close to the river is clear from the fact that epiphytic mosses occur on the trees growing here. Below the Falls the gorge is a deep, rocky chasm where the vegetation is of a succulent xerophytic type, and Bryophyta almost disappear; while before reaching the Falls the river has travelled through hundreds of miles of arid country, so that this part of its course is entirely isolated from the tropical rain-forest

in which it takes its rise. These considerations quite explain the comparative poverty of the bryophytic vegetation of what might have been expected to be a specially rich locality.

The other consideration on which I base my expectation that no large additions must be expected to the number of species contained in the following list is that derived from a comparison of the collections made by Dr. Sim and Prof. Wager in traversing practically the same ground in 1920.

The number of determinable gatherings made by Dr. Sim in this area amounted to about 220, comprising 80 species. Prof. Wager's gatherings (from Matopos and Victoria Falls) numbered 25, comprising 20 species, of which only five are additional to Dr. Sim's species, the remaining 15 being common to both lists.

Now, if the moss flora of the district were a comparatively rich one, and Dr. Sim's 80 species represented only a small percentage of the actual flora of these localities, it is extremely unlikely that only 25 per cent. of Prof. Wager's would be different, and 75 per cent. common to both; and it appears to me highly probable that these 80 species represent a quite high percentage of the whole moss flora. Of the 13 species collected by Prof. Wager about the Victoria Falls, only two were different from those collected there by Dr. Sim.

There is always a possibility, in a district under these climatic conditions, of a number of short-lived, minute annual species occurring, and only to be found for a short period after a rainy season, and therefore easily overlooked, or quite absent during a great part of the year. During the last few years Prof. Wager's collections have revealed several such in different parts of South Africa, representing three or four at present undescribed genera, mostly of the Funariaceae, and mostly showing an adaptation to distinctly xerophytic conditions. These, however, should they, or other similar species, occur in Rhodesia, are not likely to enrich the moss flora to any great extent numerically, however great their interest from a biological and taxonomic viewpoint.

I have added to the list of Rhodesian mosses a short account of some mosses from Portuguese Gaza-Land, containing a few species of exceptional interest.

Types of new species, unless otherwise described, are in my herbarium.

The mosses collected may now be systematically described. The following abbreviations are used: St. = sterile, otherwise the specimens are to be taken as fruiting; alt. = altitude. References thus—(3)—are to the bibliography at the end of the paper.

Dicranaceae.

Trematodon intermedius Welw. and Duby.—On moist sandy river bank, alt. 5,000 feet, Salisbury (Eyles, 2286); Zimbabwe, alt. 3,000 feet (Sim, 8826, 8835, 8836); 8826 was corticolous, a curious condition for a Trematodon.

Var. *nanus* Welw. and Duby. Syn. *Trematodon pechuelii* C.M. in "Flora," 1886, p. 508.

On damp earth bank, alt. 4,800 feet, Salisbury (Eyles, 2169).

I have not been able to see a specimen of *T. pechuelli*, but there can be no doubt that it is the same thing as this variety. C. Mueller does not compare it with *T. intermedius*; the description suggests no difference. Roth ("Die Aussereuropaisch. Laubm.," I, pp. 255, sqq.) does not mention the var. *nanus;* he does not compare *T. pechuelli* and *T. intermedius* specially, but he gives as the one character separating the former from this and other species the excurrent nerve (in *T. intermedius* almost or quite precurrent). I have examined original specimens of Welwitsch's (Nos. 9 and 20). In the former the nerve usually ceases below the apex, but is occasionally quite distinctly excurrent. In the latter (var. *nanus*) it is generally, perhaps normally excurrent. This disposes of the character as giving any value to *T. pechuelii.* In no other way but the shorter seta does the var. *nanus* differ from the type, and intermediate forms occur frequently. Some plants of Sim, 8836, might be placed here.

T. intermedius may be quite gymnostomous, or it may have a very rudimentary peristome consisting of fragmentary bases of teeth. This latter condition occurs in the specimen of Eyles, 2169. No. 2286 does not show any trace of peristome.

General distribution: Angola, Belgian Congo, Uganda, Transvaal.

Trematodon mayottensis Besch.—Rua R., near Salisbury, alt. 5,000 feet (Eyles, 1343); Matopos, alt. 4,600 feet, on wet sandy bank (Eyles, 935); Acropolis, Zimbabwe (Sim, 8819). New to the African continent. A very distinct species in the very widely pointed, obtuse leaves. No. 935 has the peristome in good condition; the teeth are long, *undivided*, densely vertically striolate; spores 22μ to 25μ.

General distribution: Mayotte.

Trematodon flexifolius C.M.—Victoria Falls, alt. 3,000 feet (Sim, 8936, 8940).

Agrees quite well with the description of *T. flexifolius*. Notable for the extremely long collum, and closely allied to the northern *T. longicollis*. New to continental Africa.

General distribution: Island of St. Thomé.

Trematodon africanus Wager, in "Trans. Roy. Soc. South Africa," IV, 4.—On wet ground under short grass, Rua R., near Salisbury, alt. 5,000 feet (Eyles, 1341, 1342).

General distribution: Transvaal, Natal.

Aongstroemia gymnomitrioides sp. nov. Dixon.

Rupestris. E speciebus generis africanis *A. julaceae* Hook. proxima, longe tamen aliena; robustior, caespites densos, siccitate pallide olivaceos madore laete virides, facile dilabiles, efficiens; habitu omnino specierum nonnullarum Gymnomitrii, e.g., *G.*

obtusum (Lindb.). Caulis circa Icm. altus, inferne fastigiate divisus, tenellus, filiformis, *siccus madidusque maxime julaceus, teres*, apice obtuso; folia *densissime julaceo-imbricata, e basi latissima amplexicauli circularia*, perconcava, *integerrima;* costa tenella, ubique aequalis, longe infra apicem terminata. Cellulae *ubique, nisi marginales, subaequales, quadratae, magnae.* 15μ ad 20μ latae, perchlorophyllosae, parietibus tenuibus, firmis; marginalibus seriebus I-ʺ saepe angustiores, rectangulares, saepius echlorophyllosae, hyalinae.

Dioica. ♂ planta sola visa. Flos ♂ apicalis (cito tamen propter innovationemsingulam lateralis visus), conspicuus, bracteiis perigonialibus pallidis, ovatis, longe acuminatis aristatisque subfalcatis, antheridia pauca, parva includentibus. Cetera ignota.

Habitat: On flat rocks, Zimbabwe, alt. 3,000 feet (Sim, 8747); on granite, Matopos, alt. 5,000 feet (Sim, 8772, 8850); Khami, alt. 5,000 feet (Sim, 8838).

A remarkable moss, closely related to the equally peculiar *A. julacea* Hook., but that has crenulate-denticulate leaves, a much wider nerve, and very different upper cells. The ♂ flowers are very conspicuous, the bracts being much larger and longer than the stem-leaves.

The resemblance to some species of the genus Gymnomitrium of Hepaticae is very striking.

Dicranella subsubulata Hampe.—Inyanga, on wet earth, with *Polytrichum commune*, alt. 6,000 feet. (Dr. Nobbs, 1361, in herb. Eyles).

General distribution: Cape Province, Natal, Transvaal.

Leucoloma chrysobasilare (C.M.) Jaeg. Syn. *Leucoloma woodii* Rehm. and MacLea in sched. (Rehm. "M. Austr.-Afr.," No. 444).

In wet forest, Inyanga, alt. 6,000 feet (Henkel. 2624, 2635b in herb. Eyles). Further records are: Woodbush, Transvaal, Rehmann (original of *L. woodii* (st.); and from the same locality, J. Hewitt, 1910. No. 2, herb. Dixon, c.fr. Usagara Mts. Hannington, and Usagara Mts. Last both ex herb. Mitten; these latter sterile.

General distribution: Comores, Mascarenes, Madagascar, East tropical Africa, South Africa.

The two specimens from Mitten's herbarium were determined by him as *I. chrysobasilare*, and I quite concur with his identification of them with the Anjouan moss. *L. woodii* is precisely the same thing.

The fruit (first described by Wager in "Trans. Roy. Soc. S. Afr." IV, 2) is turgidly elliptical, on a very short seta rather less than its own length, so that the capsule is hardly exserted; it is in fact very similar to that of *L. bifidum* Brid.

Leucoloma rehmanii (C.M.) Rehm.—Inyanga, alt. 6,000 feet, in wet forest (Henkel, 2623b, 2635 in herb. Eyles), the latter cum setis.

General distribution: Cape Province, Transvaal.

Campylopus nano-tanax C.M.—Acropolis, Zimbabwe, alt. 3,250 feet (Sim, 8820) St.
General distribution: Zululand, Transvaal.

Campylopus angustinervis sp. nov. Dixon.

Humilis, caespites *densissimos*, olivaceos, vix 1 cm. altos instruens. Folia *parva*, 2.5 mm. ad 3.5 mm. longa, *stricta*, sicca plerumque parum mutata, raro subflexuosa *per totam longitudinem valde convoluta, tubulosa;* lineari-lanceolata, superne convoluta, dorso scaberula, apice cito brevissime raro longiuscule hyalino-cuspidata. Costa angusta, $\frac{1}{4}$ ad $\frac{1}{3}$ folii latitudinem inferne occupans; sectione tenuis, duces parvos, cellulas ventrales subaequales vel minores, *dorsales substereideas tantum* exhibens. Cellulae basilares rectangulares, *hyalinae, parietibus tenuibus*, marginum versus angustissimae, limbum latum hyalinum instruentes, alares *nullae*, superiores *anguste rhomboideae*, parietibus tenuibus, sinuosis.

Theca (a cl. Mitten delineata) seta perbrevi cygnicolli elliptica, symmetrica, operculo conico-rostellato, calyptra basi longe fimbriata, peristomio (ut videtur) dicranaceo.

Habitat: In deep green tufts, The Downs, Pietersburg, alt. 4,000 feet, Transvaal, November, 1918 (Rev. H. A. Junod, 4001 in herb. Sim); Belfast, 1919 (Wager, 884); Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8862); Zimbabwe, alt. 3,000 feet (Sim, 8789, 8806); "On earth at Camp," Central Africa (Hannington, in herb. Mitten, unnamed; three different gatherings, one, fide Mitten, c.fr.). All the above plants with this exception sterile.

A very distinct species in the habit, the position and convolute form of the leaves when dry, the narrow nerve, and the cell structure of the latter and the lamina. The nerve shows, as far as I have examined it, only three layers of cells, all subequal, but varying in relative size to some considerable extent either in different leaves or at different positions in the leaf. The guide-cells and those of the ventral layer are sometimes subequal, at other times the latter are much smaller, and the row of guide-cells is then very much nearer the front of the nerve. The dorsal cells are substereid and obscure, forming a rather thicker layer, but I have not found actual stereid cells, and am inclined to place the plant in the Subgenus Pseudo-campylopus.

C. cailleae Ren. and Card. from Nossi Comba is the most closely allied species, but that has auricles moderately developed.

It is rather curious that the above eight gatherings of this undescribed species by four different collectors, from such different parts of Africa, all came into my hands within the space of about a month.

Campylopus lepidophyllus (C.M.) Jaeg.—Zimbabwe, alt. 3,000 feet (Sim, 8785) St.

This agrees well with an original specimen in Hampe's herbarium. The guide-cells of the nerve are very small compared with the cells of the ventral face.

General distribution: Cape Province.

Campylopus trichodes Lor.—Zimbabwe, alt. 3,000 feet (Sim, 8749, 8829); Matopos, alt. 5,000 feet (Sim, 8950). All sterile. A highly variable species in colour, size and development of hair-point.

General distribution: South Africa generally.

Var. nov. *Perlamellosus*. Dixon.

Elatus. Costae lamellae superioris altissimae.

Habitat: Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8858), St.; Bed of Tugela River, Natal, alt. 6,000 feet (Dr. Bews, 8374 in herb. Sim) St.

The dorsal lamellae are pronounced in *C. trichodes*, and vary considerably, but they are so highly developed here that the plant seems worthy of varietal rank. A section of the nerve near the base scarcely shows them, but in mid-leaf their height is sometimes actually equal to the thickness of the whole of the rest of the nerve-section. Both the plants referred to the var. are unusually robust, but this may not be more than a coincidence.

Campylopus inandae (Rehm.) Par.—Zimbabwe, alt. 3,000 feet (Sim, 8739, 8740, 8784, 8827) St.; Rhodes' Grave, Matopos, alt. 5,000 feet. (Sim, 8874) St.; Wet Forest, Inyanga, alt. 6,000 feet (Henkel, 2635c in herb. Eyles) St.

This is one of the most striking of the South African species of Campylopus, generally growing in tall, loose tufts with a bronze sheen. It varies greatly in habit, and a single tuft may exhibit several distinct forms. The hair-point appears to be usually only slightly developed, but it may be long and conspicuous. Henkel's plant is shorter, bright green, with falcate leaves, probably a shade form.

The anatomical structure is distinct, the nerve in section being thin, with the guide-cells very near the front, the ventral layer extremely thin, of very small stereid or substereid cells. The auricles are large and conspicuous, the supra-alar cells all shortly rectangular, not or little narrowed at margin.

General distribution: Natal.

Sim's collections contained one or two other species of sterile Campylopus, one quite probably an undescribed one, but their condition scarcely allowed of accurate determination.

Leucobryaceae.

Octoblepharum albidum (L.) Hedw.—I have received five gatherings from Southern Rhodesia of this moss, almost cosmopolitan in the tropical and subtropical regions of the world. It reaches as far south as Natal. Recorded also from the Victoria Falls by Brotherus (2).

FISSIDENTACEAE.

Bryoidium.

Fissidens androgynus Bruch.—Victoria Falls, alt. 3,000 feet (Sim, 8881, 8903, 9826, 8929, 8946); Victoria Falls (Wager, 890 p.p., 901); Cataract I., Victoria Falls (J. Burtt-Davy, 17,829). All c.fr. This distinct, synoicous species is evidently abundant about the Falls. The stout, often reddish border, recalls *F. rufulus.*

General distribution: Cape Province.

Fissidens cuspidatus C.M.—Bulawayo (Wager, 895 p.p.) St.

General distribution: Cape Province, Natal, Transvaal.

I am moreover quite unable to distinguish from this species a plant from the Himalayas, and I am inclined to think it may prove to be a widely distributed species under several names.

Fissidens latifolius sp. nov. Dixon.

Caespitosus vel dense aggregatus sat robustus plerumque corticola, atro-viridis. Caulis saepius simplex, usque ad I cm. longus, plus minusve procumbens, strictiusculus. Folia madida complanata, *sicca crispo-falcata*, haud conferta, *late oblongo-lanceolata*, *breviter late acuta saepe obtusiuscula apiculataque.* Lamina vaginans paullo dimidiam partem folii superans, summo apice acute *ad mediam partem laminae terminata*, lamina dorsalis folii basin attingens ibique *saepe perlata* vix auriculata, angustissime decurrens

Folii margines omnes limbo hyalino *perangusto*, *dorso saepe angustissimo*, *nonnumquam carente*, circumdati. Costa sat valida, superne subflexuosa, concolor, percurrens vel infra summam apicem evanescens. Cellulae parvae circa 7μ, laeves, chlorophyllosae, *perdistinctae*, subrotundatae hexagonaeve, *saepe pulchre seriatae*, parietibus firmis, tenuibus. Seta longiuscula, 6 mm. ad 8 mm. alta, purpurea; theca *inclinata*, *gibbosa*, *perbrevis minuta.* Peristomium normale.

Habitat: Zimbabwe, alt. 3,000 feet (Sim, 8766) c.f.; 8807 c.fr.; 8753, 8761 and 8768, St.); Khami Ruins, alt. 5,000 feet (Sim, 8841, St.); Matopos, alt. 5,000 feet (Sim, 8856 c.fr.); on ground in shade, Salisbury, alt. 4,900 feet (Eyles, 1574).

The nearest species is probably *F. subremotifolius* C.M., which I have not seen, but the description of that does not agree in several points, especially "pedunculo et perostomio brevissimo" and "nervo ferrugineo." The wide, not tapering, leaves are characteristic. The vaginant lamina terminates neither on the nerve nor at the margin, but in the middle of the lamina, an unusual position.

From its distribution and characters it seems to be as distinctly xerophytic as *F. androgynus* is hygrophytic.

Fissidens dubiosus sp. nov. Dixon.

Robustus, atovurens; caules *elongati*, ad 2 cm. longi, simplices, *pulcherrime plumosi*, latitudine ubique fere aequali, circa

3 mm. Folia multijuga, 1.5 mm. ad 1.75 mm. longa, confertiuscula, *late elliptico-oblonga, obtusa vel apiculata;* lamina vaginans *vix dimidiam partem* superans, lamina dorsalis ad basin folii attingens ibique cito angustata. Costa validiuscula, infra subferruginea, *infra apicem soluta.* Lamina vaginans *limbo saepe rufescente sat valido*, 2 ad 4 seriato circumdata; lamina dorsalis et apicalis *nunc angustissime limbata, nunc omnino immarginata.* Cellulae *majusculae*, 12μ ad 16μ latae, subquadratae, *perchlorophyllosae*, laeves, parietibus tenuibus. Fructus ignotus.

Habitat: Palm Grove, Victoria Falls, alt. 2,500 feet (Sim, 8819).

A very beautiful and distinct species, with prettily plumose foliage, almost elliptical, often obtuse leaves, nerve ceasing distinctly below apex, and large, highly chlorophyllose cells. The border (except on the vaginant lamina) is very narrow, often indistinct, sometimes altogether wanting, sometimes indicated only by occasional elongate 1-2-seriate, but not cartilaginous cells The species might, therefore, be considered to belong to the Semilimbidium; but the occasional full development of the border, together with the character of the aerolation, leave little doubt that its true place is in Bryoidium.

Semilimbidium.

Fissidens micro-androgynus sp. nov. Dixon.

F. androgyno Bruch structura, inflorescentia synoica, etc., *similis, multo tamen pusillior*, vix 0.5 cm. altus; folia 5 ad 7 juga, remotiuscula, *omnino nisi apud laminam vaginantem immarginata, ibique angustissime limbata.* Seta perbrevis, 3 mm. alta; theca *perminuta, brevis, erecta vel inclinata, sicca urceolata*, operculo *conico*, acuto.

Habitat: Bulawayo (Wager, 895).

Almost a miniature of *F. androgynus* Bruch, but totally distinct in the size and the characters italicised. The synoicous inflorescence and the pale, chlorophyllose, clear, smooth cells, will distinguish it from others of the South African Semilimbidia. The very narrow border is frequently to be found only on the upper, or the perichaetial leaves, the lower leaves being entirely unbordered.

Fissidens submarginatus Bruch.—On ant-hill in granite country, Umtali, alt. 3,700 feet (Eyles, 1742).

General distribution: Cape Province, Natal.

Aloma.

Fissidens calochlorus sp. nov. Dixon.

Pusillus; dense caespitosus *intense laete viridis.* Caulis fertilis circa 2 mm. longus, paucijuga; sterilis paullo longior, plurijuga. Folia caulis fertilis ligulato-lanceolata, acuta, raro breviter acuminata; lamina vaginans dimidiam partem folii superans, lamina dorsalis ad folii basin attingens, ibique saepe rotundata; omnes immarginatae, *integrae;* costa valida, concolor, *flexuosa*,

infra apicem soluta. Cellulae *perpellucidae*, chlorophyllosae, 9μ ad 11μ latae hexagonae, parietibus tenuibus, pellucidis. Folia caulis sterilis remotiuscula, *latiora*, *oblongo-elliptica*, acuta. Folia siccitate *leniter flexuosa*, *parum mutata*.

Rhizautoica; planta ♂ gemmacea, polyphylla.

Seta *brevissima* 2 mm. ad 3 mm.; flava; theca erecta vel inclinata, *minuta*, plus minusve 0.5 mm. longa, operculo conico-rostellato.

Habitat: Below the Victoria Falls, alt. 2,500 feet (Sim, 8891) c.fr. paucis; Victoria Falls, alt. 3,000 feet (Sim, 8882) St.

Although one of the smaller species this is by no means an inconspicuous plant, forming fair-sized tufts of a vivid green colour. Dr. Sim remarks that it is a first pioneer on moist bare rocks.

F. cryptarum C.M. is perhaps the nearest species, but is a much larger plant, with reddish nerve, etc. *F. holstii* Broth. has narrower, strongly apiculate leaves.

Crenularia.

Fissidens erosulus (C.M.) Par.—Zimbabwe, alt. 3,000 feet (Sim, 8883); Victoria Falls, alt. 3,000 feet (Sim, 8887; Wager, 912); Matopos, alt. 5000 feet (Sim, 8846).

This agrees very well with C. Mueller's original plant; these three specimens, as in that, show some slight variation in the width of the leaf and the degree of acuteness of the point; they are always, however, wider above and less acuminate than in *F. sarcophyllus* C.M., frequently almost obtuse, and sometimes quite so. The leaves are laterally very asymmetric, the nerve being generally much nearer one side than the other. The cells are obscure and very opaque, very densely and minutely, almost invisibly papillose. Traces of an evanescent border are sometimes visible on the vaginant lamina of the uppermost or perichaetial leaves.

General distribution: Niam-Niam, Uganda, Portuguese East Africa.

Crispidium.

Fissidens rotundatus sp. nov. Dixon (V. infra, p. 332).—Tatagura Valley, Mazoe, alt. 4,300 feet (Eyles, 653) c.fr.

Amblyothallia

Fissidens procerior Broth. and Bryhn.—Victoria Falls. Recorded by Brotherus (2). The only known locality, except the original one in Zululand (3).

Serridium.

Fissidens corrugatulus sp. nov. Dixon.

Robustus, caespites latos, *rigidos*, atrovirides, aetate fuscescentes instruens. Caulis simplex vel hic illic innovans; ad 2 cm. altus, circa 3 mm. latus. Folia conferta complanata, sicca *fortiter*

rigide falcata vel hamata, 2 mm. ad 2.5 mm. longa, e basi latiore *late oblonga* apice abrupte obtuse acutata, apiculata, nec acuminata; lamina vaginans circa 2/3 folii longitudinem attingens; lamina dorsalis ad basin folii accedens ibique auriculata margines omnes tenerrime crenulati. Costa valida, concolor, superne plus minusve sinuosa, percurrens. Lamina folii *superne madida plus minusve fortiter transverse rugosa*. Cellulae perchlorophyllosae, pellucidae, laeves, 9μ to 12μ latae, subrotundatae, marginales haud distinctae.

Cetera ignota.

Habitat: Victoria Falls, alt. 3,000 feet (Sim, 8885, 8904, 8924 p.p. 8928); Matopos, alt. 5,000 feet (Sim, 8878).

This species appears best placed in this section rather than in Amblyothallia. It has no near allies among the African species; the nearest perhaps is *F. procerior* Broth. and Bryhn; but there, as in *F. cymatophyllus* C.M. and *F. amblyophyllus* C.M., the texture is quite different, the leaves much longer and narrower, ligulate, and with a different nerve. They are also without a transverse corrugation which is very constant here, and a marked feature when moist.

I must confess to a little suspicion as to the origin of No. 8878. Dr. Sim tells me that he thinks there is no doubt that the data are correctly given. The species is, however, in all the other gatherings definitely hygrophytic in its habit and associates, and it seems a little remarkable that a single gathering should come from the Matopos, while betraying no difference whatever in character. The collecting number, moreover, is the last of those belonging to the Matopos, the following and succeeding numbers being from the Victoria Falls.

Octodiceras.

Fissidens julianus (Savi) Schimp.—Mazoe, alt. 4,600 feet, submerged (Eyles, 401); Palm Grove, Victoria Falls, alt. 2,500 feet (Sim, 8917); Victoria Falls (Wager, 911); Umtali, in running stream, alt. 3,800 feet (Eyles, 1663). All sterile.

General distribution.—Aquatic. Very widely spread in north and south temperate latitudes.

Calymperaceae.

Calymperes victoriae, sp. nov. Dixon.

Climacina. *C. tenello* C.M. affine; multo brevius; *pusillum*, circa 0.5 cm. altum, *viride*. Folia sicca convoluta. Hamato-incurva, madida explanata, concava, 2 mm. ad 3 mm. longa, supra basin *brevem angustiorem* paullo constricta, inde *oblongo-ovata*, apice *paullo angustata*, obtusa, marginibus ad medium folium seriebus duabus cellularum bistratosis, crenulatis vel *hic illic minute denticulatis;* costa validiuscula, 45μ ad 50μ lata; per totam longitudinem subaequalis, seu sensim superne paullo angustata, dorso papillata. Cellulae basilares endohyalinae

magnae, brevissime rectangulares, subqudratae, seriebus superne perdistincte, nec alte scalaribus. Cellulae marginales basilares inter teniolam marginemque 4 ad 7 seriatae, quadratae, chlorophyllosae, limbum infra sensim attenuatam instruentes, ad basin 1 ad 2 *seriatum,* e cellulis breviter rectangularibus hyalinis instructum; margine basilari *ubique teneriter denticulato.* Teniola bene notata, ubique fere biseriata (aliquando tri-seriata) *supra basin evanescens, raro ad medium folium attingens.* Cellulae superiores rotundae vel hexagonae, minutae, 3μ ad 5μ latae, chlorophyllosae, distinctae, dorso *papillosae.* Fructus ignotus.

Habitat: Victoria Falls, alt. 3,000 feet (Sim, 8879).

A rather commonplace little plant, but apparently distinct from anything yet described, *C. tentellum* C.M. and *C. brachypelma* C.M. are taller, with longer and narrower, involute leaves, indistinct teniole, and cells mamillose at back but not papillose. *C. orthophyllaceum* C.M. is more robust, with more coarsely serrate leaves and involute margins.

It marks the southern limit of the distribution of Calymperes in continental Africa.

Pottiaceae.

Hymenostomum socotranum Mitt.—Odzani R. Valley, Manica, Umtali Prov. (A. J. Teague, 167); Lomagundi, Darwindale, in picrite formation, alt. 4,500 feet (Eyles, 697); Matopos, alt. 5,000 feet (Eyles, 1049, 1051). All c.fr.

Agrees quite well with Mitten's plant, which, however, is extremely close to *H. tortile.*

General distribution: Socotra.

Hymenostomum humicola (C.M. Par.—Rua R., near Salisbury, alt. 5,000 feet, on stem of Vellozia (Eyles, 1345); on earth between rock and tree, Salisbury, alt. 4,900 feet (Eyles, 684b, Herb. Mus. Brit.); Zimbabwe, alt. 3,000 feet (Sim, 8813); Matopos (Wager, 892, 915); Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8863; Wager, 890). All c.fr. The rather large, clear cells separate this species markedly from most of its congeners.

General distribution: Cape Province.

Hymenostomum eurybasis sp. nov. Dixon. (For description v. infra).—On earth, Matopos, Mchelele Valley, alt. 4,700 feet (Eyles, 940, 941).

General distribution: Portuguese Gaza Land (V. infra).

Gyroweisia latifolia sp. nov. Dixon.

Humilis, dense caespitosa, sordide viridis, infra pallescens. Caulis circa 5 mm. altus, filiformis. Folia laxiuscula, erectopatentia, sicca *vix mutata, minima,* 0.3 mm. ad 0.4 mm. longa, *latissime oblongo-lingulata, vel suborbicularia, apice valde obtuso, rotundato, concava, utroque latere prope marginem leniter sulcata, marginibus ipsis recurvatis,* integris. Costa valida, *lata* supra parum angustata, sub summo apicem evanescens, dorso plus minusve, saepe alte, scaberulo.

Cellulae basilares quadrato-rectangulares, pellucidae, superiores *parvae*, 5μ ad 8μ, irregulares, subrotundae, obscurae, mamillosae, parietibus *tenuibus*, *pellucidis*, subcollenchymaticis.

Seta 5 mm. ad 7 mm. longa, rubra; theca *parva*, *elliptica*, 1 mm. longa, pachydermica, castanea, gymnostoma (?), operculum haud visum.

Habitat: Dry area, Victoria Falls (Sim, 8931).

A very pretty and distinct little moss in the broad, rounded leaves scarcely or not at all altered when dry, as well as in other characters. *G. mosis* (Lor.) somewhat resembles it, but has markedly longer and narrower leaves.

Hymenostylium crassinervium Broth. and Dixon in Smithson. Miscell. Colls., 69, No. 2, p. 13.—Victoria Falls, alt. 3,000 feet (Sim, 8899, 8902) St.

The basal cells are a little laxer than in the type, but otherwise it agrees quite well.

Trichostomum cyathiforme sp. nov. Dixon.

Sat robustum, *atro-viride*, inferne atratum. Caules circa 1 cm. alti, caespitem densum, rigidiusculum efficientes. Folia superne *dense comata*, sicca fortiter circinato-incurva, valde convoluta, dorso pallida, brevia, 2 mm. ad 3 mm. longa, o basi brevi plerumque latiore, *saepe suborbiculari*, usque ad 1 mm. lata, in laminam duplo longiorem, *late oblongo-ovatam vel subspathulatam, concavam, cyathiformen* continuata, obtusa, rotundata, vel *ob margines superne fortiter late involutas cucullata.* Costa *pervalida* fusca, haud pellucida, dorso prominens, laevis.

Cellulae laminae 8μ ad 10μ latae, hexagonae, *perchlorophyllosae*, opacae, ob parietes firmas vix incrassatas pallidas *dictinctae*, supra plerumque sublaeves vel dorso irregulariter prominentes, inferne (supra basin) saepius, praecipue paginae ventralis, *valde papillosae*, saepe papilla singula alta apice bifida coronatae. Cellulae basilares omnes *tenerae*, *perhyalinae*, elongatae, lineares vel rectangulares, juxtacostales saepius breviores latioresque, omnes in eas laminae *abrupte* transeuntes *nisi marginales, seriebus* 2 ad 3 *hyalinae elongatae altius ascendentes*, ibidemque margine saepa leniter *denticulato*. Cetera ignota.

Habitat: Victoria Falls, alt. 3,000 feet (Sim, 8934).

The generic position of this plant cannot be certainly ascertained without fruit; it might conceivably be a Hyophila, or, of course, a Totella. It is recognisable at once by the leaf characters, the deeply concave, boat-shaped lamina with the clearly differentiated base of elongate, hyaline or pellucid, thin-walled cells, passing abruptly into the small, opaque upper ones, except at the margin, where a row or two of the basal cells ascend for some little distance upwards. The lamina occasionally on pressure flattens out entirely, and in that case the leaf base may be little or not wider, but as a rule the base is much broader, short and suborbicular, rapidly narrowed into the concave, cyathiform upper part.

Trichostomum rhodesiae Broth. in "Denkschr. der Math-Naturwissensch. K.K. Akad.," Bd. 88, p. 735 (Musci).—Victoria Falls, on trunks of trees; Brunnthaler, Victoria Falls, alt. 3,000 feet (Sim, 8901). Both sterile.

I have not seen Brotherus' species, but the description fits Sim's plant accurately. The leaves are described as "fragilia"; in Sim's plant they are very markedly fragile, and the lamina of the leaf appears to be often elongated into a narrow, ligulate, highly fragile prolongation for reproductive purposes.

Tortella caespitosa (Schwaegr) Limpricht.

Syn *Barbula afro-caespitosa* C.M. in "Hedwig.," 38, p. 109 (1899). *Tortella afro-caespitosa* Broth. in Engler and Prantl "Pflanzenfam.," Musci," 1,397 (1902).—Mazoe, on Fatagura River, alt. 4,300 feet (Eyles, 712) c.fr.

Barbula afro-caespitosa is certainly not to be separated from the northern species; C. Mueller gives no distinctions between them except for saying that the African plant is much more robust in all its parts; but a glance through any herbarium containing a good series of the northern species will show at once that this is of no weight whatever. In fact the type of C. Mueller's species is by no means specially robust. In all probability one or two other "hyphenated species" described by C. Mueller in the same place must equally go under this name; but I have not had time to examine them critically.

Tortella opaca sp. nov. Dixon.

Dense caespitosa, *atro-viridis vel sordide viridis*, humilis. Folia madida e basi erecta valde patentia vel subsquarrosa, sicca circinato-incurva, 3 mm. longa, e basi breviore hyalina paullo latiore *linealia*, supra sensim paullo angustata, *apice obtuso apiculato, cucullato*, fragilia, marginibus supra basin *fortiter late involutis, unde folia valde canaliculata subtubulosa;* costa ad basin fusca, valida (60μ ad 75μ lata), supra concolor, vel pellucida, *in apiculam hyalinum* excurrens. Cellulae basilares *hyalinae*, sed breviter rectangulares parietibus firmis; nonnunquam, praecipue juxtacostales longiores, lineares, parietibus tenuibus; marginales supra basi *haud ascendentibus;* superiores *opacae, minutae*, circa 5μ ad 7μ, subrotundae, vel subquadratae, *parietibus tenuibus, sublaeves.*

Propagula foliacea minuta elliptica ad caulis apicem rosulata, hic illic vidi.

Victoria Falls, alt. 3,000 feet (Sim, 8884, 8890).

In absence of fruit this might be placed equally in Trichostomum. It is distinct in the channelled leaves with widely involute margins, as in species Weisia and Hymenostomum, but the size and differentiated leaf base separates it from these. The terminal rosettes of elliptical brood-leaves may not be constantly present, but so far as they go they are characteristic.

Tortella obtusifolia sp. nov. Dixon.

Pusilla, caules circa 5 mm. alti. gregaria vel laxe caespitosi;

superne sordide viridis, inferne pallide rufescens. Folia *parva*, 1 mm. ad 1.5 mm. longa, supra sensim majora, *patentia*, *recurva*, sicca crispata, e basi *perbrevi*, *haud latiore*, *lingulata*, *obtusa vel minute apiculata*, marginibus *planis*, integris; costa validiuscula, superne angustata, vix pellucida, carinata, dorso laevis vel sublaevis, infra apicem soluta vel subpercurrens. Cellulae superiores *perobscurae*, *limitibus haud*, *nisi foliis senioribus*, *decernendis*, plus minusve 7μ latae, seriebus longitudinalibus dispositae; basilares haud multi rectangulares, vel lineares, hyalinae. Perichaetium *longe exsertum*, conspicuum, bracteis interioribus *convolutis*, *tubulosis obtusis*. Seta 6 mm. ad 8 mm. longa, *tenuissima*, flava; theca parva, cylindrica, late annulata, operculo breviore, cellulis spiraliter contortis; peristomium bene evolutum, sed fragile, torquatum, basi brevi tubulari aurantiaca.

Habitat: Clay bank, Umtali, alt. 4,200 feet (Eyles, 1741).

This appears a very distinct species in the small, lingulate, widely rounded and obtuse or bluntly apiculate leaves with very obscure upper cells and tubular, exserted perichaetium. The capsules are all immature, but sufficiently advanced to show that the peristome is quite barbuloid. Some African species of the same affinity have been placed under *Barbula* (*Streblotrichum*) on account of the long tubular perichaetium; but the plane-margined leaf and dense obscure upper cells appear to me to indicate Tortella; otherwise I do not see on what grounds the two genera can be kept apart.

Hyophila atrovirens (C.M.) Jaeg.—Victoria Falls, alt. 2,500 feet—5,000 feet. (Sim, 8885b, 8886, 8894, 8916, 8924, 2925). All sterile. Evidently one of the abundant species of the neighbourhood, and found both above and below the Falls. No. 8924 is a narrow-leaved form, with narrower, much less rounded apex than usual, and indeed sometimes somewhat acute; the margin is very variably dentate, often quite entire. There is nothing definite, however, to separate it from the present species.

General distribution: Natal, Transvaal, Portuguese East Africa.

Hyophila baginsensis (C.M.).—Zimbabwe, alt. 3,000 feet. (Sim, 8831) c.fr.; Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8868) St.; Victoria Falls, alt. 3,000 feet (Sim, 8880, 8883) St.

This plant differs from the preceding in the habit and colour, entire leaves. It agrees (e descr.) quite well with C. Mueller's species from Niam-Niam, and is not very closely allied to any of the other African species of the genus. *H. potieri* has strongly mucronate and narrower, oblong leaves.

General distribution: Niam-Niam.

Hyophila perrobusta Broth (2).—Victoria Falls, on tree trunks, coll. Brunnthaler.

Hyophila zeyheri (Hampe) Jaeg.—Zimbabwe Ruins, alt. 3,000 feet (Sim, 8751, 8764, 8799); Khami Ruins, alt. 5,000 feet (Sim, 8864); Matopos, alt. 5,000 feet (Sim, 8852); 8799 is in fruit, the rest sterile.

General distribution: Cape Province, Natal, Transvaal, Portuguese East Africa.

Weisiopsis plicata (Mitt.) Broth. in "Oefv. af Finsk. Vet.-Soc. Foerh.," LXII, No. 9 (1920).—On stone, mouth of cave, mostly in shade, Salisbury, alt. 5,200 feet (Eyles, 2282).

This little species, *Hyophila plicata* of Mitten, is placed by Brotherus in the new genus Weisiopsis, distinguished from Hyophila by the thin-walled, more or less plicate, peristomate capsule; and comprising five known species, the remaining four being confined to Eastern Asia.

General distribution: Usagara, Madagascar.

Didymodon afer (C.M.) Broth.—Victoria Falls, alt. 3,000 feet (Sim, 8952).

General distribution: Cape Province, Transvaal.

Wager (9) states of this species, "common"; but I rather doubt the accuracy of this comment.

Barbula indica Brid. syn. *Barbula natalensis* C.M.—Bulawayo (Sadler, 982 in herb. G. Webster) St. Earth bank, banks of the Zambesi, near Victoria Falls, alt. 3,000 feet (Eyles, 1309) c.fr.

This belongs to a perplexing series of species of very similar habit and leaf form and structure, the difficulty of determination being greatly increased by their being frequently sterile, and by the fact of their belonging to two groups, differing from one another materially in the peristome, while perhaps not exhibiting any marked vegetative differences; some having the peristome long, twisted and fully Barbuloid; while in others the teeth are short, scarcely twisted, as in Didymodon and Trichostomum. They are similar in the ligulate or lingulate outline of the leaf, obtuse or very shortly pointed, often cucullate apex, the small obscure upper cells, and especially the back of the very prominent nerve strongly papillose, often verrucose, above. The best known of these is the present species, known also as *Trichostomum orientale* Willd., occurring also in Madagascar, the Comores and Seychelles. The South African species is quite inseparable from it. Four or five African species of the group have been described, of which the following *B. stuhlmannii* is one; it is probable that some reduction may be made when the plants have been more closely studied, as the species are mostly based on slight vegetative characters which may be inconstant or varietal merely.

General distribution: India, Malay Peninsula, East Indies, Borneo, Tonkin, Formosa, New Guinea, Madagascar, Comores, Seychelles, Natal, (?) Portuguese East Africa.

Barbula stuhlmannii Broth.—Vertical sides of trench on soft travertine (70 to 90% carbonate of lime), Mazoe, 4,300 feet (Eyles, 711).

The long peristome shows that this is distinct from *B. natalensis* and that group; it agrees very well with *B. stuhlmannii* from Zanzibar, the only difference that I can detect being that the cells are very slightly more distinct than in the specimens I have seen of that species. The leaves are much narrower than in *B. natalensis*, the apex more acute, slightly cucullate, and the cells less opaque.

General distribution: Zanzibar.

Barbula salisburiensis sp. nov. Dixon.

B. xanthocarpae C.M. affinis, differt foliis *angustioribus*, ab insertione usque ad apicem sensim angustatis, nec acuminatis, subobtusis vel obtusis, costa dorso valde prominente, subpercurrente, margine a basi usque fere ad apicem *fortiter revoluto*, cellulis *omnibus pellucidis*, inferioribus breviter rectangularibus, parietibus firmis, sensim in superiores *subquadratas atque breviter rectangulares* transeuntibus. Folia perichaetialia foliis caulinis similia. Seta 1 cm. alta, pallide rubra. Theca elliptica, 1.5 mm. longa, *leptodermica*, *exothecii cellulis perlaxis*, irregularibus, parietibus tenuibus. Peristomium praelongum, thecae longitudinem subaequans, dentibus torquatis, pulchre rubris.

Habitat: On bank of stream, schist formation, Salisbury, alt. 4,900 feet (Eyles, 596). In small quantity, but apparently quite a good species. *B. xanthocarpa* C.M. has wider, more opaque leaves and very different capsule. I do not know why it is placed under Streblotrichum by Brotherus, as the perichaetial leaves are in no way differentiated from the ordinary ones.

The form of the leaves, narrowed almost from the point of insertion, and with no differentiated basal part, the strong, prominent nerve, pellucid cells, and the structure of the capsule, are marked features in the present plant. Most of the allied African species, of at all similar habit, moreover, have the upper cells obscure and opaque and the nerve scabrous at back above.

Barbula elongata sp. nov. Dixon.

Perrobusta, 3 cm. ad 5 cm. alta caespites *rigidos* olivaceo-virides, laxe cohaerentes formans. Folia patentia, sicca *rigide incurvo-flexuosa*, 1.5 mm. ad 2 mm. longa, aequalia nec comosa, *laxiuscule disposita*, e basi latiore sensim ligulato-lanceolata, late acuta, nec acuminata, perconcava, carinata *ad margines longitudinaliter anguste plicata*, marginibus ipsis nunc revolutis nunc erectis. Costa valida, subpercurrens, dorso *superne scabriuscula*. Cellulae superiores sat distinctae, chlorophyllosae 7μ ad 9μ latae, basilares *brevissime rectangulares* (vix 1.5 $\times$ 1), parietibus firmis, parvae, pellucidae. Cetera ignota.

Habitat: Danger Point, Victoria Falls, alt. 3,000 feet (Sim, 8895); Victoria Falls, alt. 3,000 feet (Sim, 8897, 8898).

In the stout canaliculate nerve, scabrous above, the form and submarginal plicae of the leaves, this seems to be allied to *B. indica*

(Schwaegr.) and the allied species of that group (*B. natalensis*); but the tall, robust, very rigid stems, the rigidity of the leaves, etc., give it a totally different character; the back of the nerve, too, is less highly scabrous. Fleischer's f. *sterilis* of *B. indica* shows some approach to it, and perhaps indicates a real affinity.

Barbula torquatifolia Geheeb.—Matopos (Wager, 898) St.

A distinct species, hitherto only known from South-West Africa, the leaves strongly twisted when dry, with broadly recurved margins, rather large cells, and stout nerve excurrent in a long cuspidate point. *B. acutata* C.M. is described as having the nerve only shortly mucronate, and the leaves lanceolate-acuminate; here they are oblong-lanceolate, and very little narrowed above.

General distribution: South-West Africa.

Phascum leptophyllum C.M.—Zimbabwe, alt. 3,000 feet (Sim, 8711); Matopos, alt. 5,000 feet (Sim, 8857). Both sterile.

General distribution: Cape Province, Transvaal.

Tortula brachyaechme (C.M.) Broth.—Zimbabwe, alt. 3,000 feet (Sim, 8732, 8752); Khami Ruins, alt. 5,000 feet (Sim, 8837). Mostly in poor fruit.

General distribution: Cape Province, Natal.

I am increasingly doubtful whether this is separable from *T. erubescens*.

Tortula erubescens (C.M.) Broth.—Zimbabwe, alt. 3,000 feet (Sim, 8773) St.; Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8872a, 8873) St.

General distribution: Eastern Africa from Cape Province to Abyssinia and Somaliland; cf. (4).

Tortula eu-bryum (C.M.) Dixon.—Zimbabwe, alt. 3,000 feet (Sim, 8736, 8780); Rhodes' Grave, alt. 5,000 feet (Sim, 8859, 8869). All sterile. The Zimbabwe plants in fine large tufts, with stems an inch high.

General distribution: Tropical East Africa, Transvaal.

GRIMMIACEAE.

Ptychomitrium crispatum (Hook. and Grev.) Schimp.—Zimbabwe, alt. 3,000 feet (Sim, 8754, 8798, 8813); Khami Ruins, alt. 5,000 feet (Sim, 8865); Matopos, alt. 5,000 feet (Eyles, 1048).

General distribution: Cape Province, Transvaal.

Ptychomitrium marginatum (Wager and Dixon), Dixon Comb. Nov. (Syn. *Glyphomitrium marginatum*, Wager and Dixon in "Trans. Roy. Soc. South Africa," VIII, 196 (1920).—On rock with south aspect, in kloof, Forest Hill Kop, Makoni (Eyles, 838).

General distribution: Cape Province, Transvaal.

Ptychomitrium eurybasis sp. nov. Dixon.

E robustioribus generis. Ab omnibus speciebus africanis

differt foliis e basi brevi *dilatata*, *obovata*, cito in laminam anguste lingulatam, obtuser acutam contractis, cellulisque *distinctis*, perchlorophyllosis, *majusculis*, 10μ ad 12μ latis, basilaribus sensim elongatis, rectangularibus, infimis juxtacostalibus elongatis, linearibus, teneris, pellucidis. Costa valida, ad basin 70μ ad 90μ lata, subpercurrens. Folii margines erecti, integri vel apice obsolete sinuosi, nullo modo incrassati. Seta *perbrevis*, 3 mm. longa, theca *parva*, *turgide elliptica*, collo sat distincta, operculo plus minusve breviter rostrato.

Habitat: Matopos, alt. 5,000 feet (Sim, 8851); Zimbabwe, alt. 3,000 feet (Sim, 8808); on granite rocks, Macheke, alt. 5,000 feet (Eyles, 1994).

Quite distinct in the rather large, not obscure, chlorophyllose cells, the dilated base of the leaves, wider above and obovate or suborbicular, the very short seta.

It may be of help to give here a tentative key to the South African species of Ptychomitrium.*

1

Leaf margin at least in some parts bistratose 2
Margin unistratose 3

2

Setae 3 mm. to 5 mm., frequently in pairs; deoperculate capsule about 1 mm. long ... ... *subcrispatum* Ther and P. de la Varde.
Seta 5 mm. to 10 mm., single, capsule about 2 mm. ... ... *marginatum* (Wager and Dixon).

3

Leaves distinctly cucullate at apex, seta very short ... ... *cucullatifolium* (C.M.).
Leaves not or not markedly cucullate 4

4

Upper cells minute, opaque, leaves not markedly widened at base 6
Upper cells larger, distinct 5

5

Base not markedly widened ... ... *crassinervium* (Schimp.)
Base markedly widened ... ... *eerybasis* (Dixon).

6

Basal margin widely recurved ... ... *depressum* (C.M.)
Margin erect or nearly so 7

7

Leaves strongly crispo-circinate when dry ... ... *crispatum* (Hook and Grev.).
Leaves scarcely crisped when dry† ... ... *obtusatum* (C.M.).

---

* *P. mucronatum* Schimp. e C. M. in "Hedwig," 38, 122, does not belong to this genus. Original specimens in herb. Schimper at Kew show it to be a Trichostomum or allied genus.

† I take this from C. Mueller's description; I have seen no specimens. It appears e descr. to differ little from *P. crispatum*.

Orthotrichaceae.

Orthotricium sp. Eyles (8).—Matopos, No. 1052.

[*Ulota crispa* B. and S. Matopos (Eyles, 1048).—Recorded by Eyles (8). Dr. Sim has sent me part of this gathering, which belongs to *Ptychomitrium crispatum* (Hook. and Grev.) Schimp.]

Macromitrium confusum Mitt.—Zimbabwe, alt. 3,000 feet (Sim, 8777, 8802, 8822).

The South African species of the subgenus Macrocoma are very perplexing, and I cannot claim to understand them. The peristome here is quite absent, and the plants agree quite well with Mitten's specimens of *M. confusum* at Kew. I therefore place it here, but with some doubt whether the name may not have to give way to some earlier one.

Macromitrium mannii Jaeg. "Adumbr.," I., 421.

Syn. *M. menziesii* Mitt. in "Journ. Linn. Soc.," Bot., VII, 152 (1863). *M. undatifolium* C.M. in "Flora," 1886, p. 278. *M. rugifolium* C.M. e Broth., in "Engl. Bot. Jahrb.," 24, p. 241 (1897).

Inyanga, alt. 6,000 feet. (Henkel, A.)

I have compared this with Mitten's type, with which it agrees quite well, as it also does with a specimen of *M. undatifolium* (Ambosita, Madagascar, Rev. Soula, 1890) sent me by Cardot. I have also compared *M. rugifolium* C.M. (Dus., M. Camer., 263) with Mitten's plant, and I am unable to find any valid specific difference between the two. Brotherus in his description of *M. rugifolium* separates it from *M. annii* and *M. undatifolium* "rigiditate, foliis brevioribus, horride patulis, valde rugosis, apice angustius serrulatis." I find, however, no difference whatever in the Madagascar plant from *M. rugifolium* in the position or the rugosity of the leaves; while they are more sharply toothed rather than less so. They are perhaps a little longer, about 3 mm. as compared with 2.5 mm. in *M. rugifolium*, but on the present plant both can be matched by leaves from the same stem; and the leaves of Mitten's type of *M. annii* are often at least no longer than those of *M. rugifolium*.

Mitten's species is well represented at Kew, and is in good fruit. Some of the ripe capsules are quite smooth, and others are deeply plicate, the difference being due, probably, to some difference in their age at the time of drying. This makes one suspicious as to the real distinctness of *M. perundulatum* Broth., which is separated from *M. undatifolium* and *M. rugifolium* only by the plicate capsule.

General distribution: S. Thomé, Cameroons, Madagascar.

Rhachithecium transvaaliense (C.M.) Broth.—Mazoe, Ironmask on tree trunks, alt. 5,000 feet (Eyles, 616b); Salisbury, on tree trunk, alt. 4,900 feet (Eyles, 1573). The former c.fr., the latter, a few sterile stems only; in both cases mixed with Fabronia.

General Distribution.—This rare and interesting little plant which has figured variously under the genera Hypnodon, Zygodon, and Decodon, has hitherto been recorded only so far as I know, from the original station in the Transvaal.

R. demissum (C.M.) is erroneously recorded by Wager in the Check List of the Mosses of South Africa; it is an Argentine species.

Schlotheimia percuspidata C.M.—Tree trunk, Inyanga, alt. 6,000 feet, Dr. Nobbs (1358 in herb Eyles). A rather marked species, being more loosely tufted and with longer branches than in most; the leaves are very little contorted when dry; the calyptra is smooth. Rehmann's specimen of "*S. cuspidata*" agree very well. It is not obvious why C. Mueller changed Rehmann's name; or rather his own MS. name.

General distribution: Cape Province.

FUNARIACEAE.

Physcomitrium spathulatum C.M.—Salisbury, in flower pots, cool house (Eyles, 1446, 1590, 1746). Victoria Falls, alt. 3,000 feet (Sim, 8941.)

General distribution: Cape Province, Natal, Portuguese Gaza Land.

Funaria marginata (C.M.) Broth.—In wet forest, Inyanga, alt. 6,000 feet. (Henkel, 2622 in herb. Eyles.)

General distribution: Cape Province, Transvaal.

Funaria longicollis sp. nov. Dixon.

Stirps distincta, foliis late obovatis, subobtusis, *immarginatis*, marginibus superioribus *ubique conferte, breviter obtuse sed distincte serrulatis*, nervo *in cuspide brevi* stricta vel reflexa excurrente. Cellulae superiores hexagonae chlorophyllosae, marginales *nullo modo angustiores*, conformes nisi *saepius hyalinae, valde prominentes*. Seta erecta, crassiuscula, rubra, circa 1cm. alta vel paullo brevior; theca *erecta vel suberecta, breviter cylindrica, cum collo aequilongo* defluente 2.5 mm. ad 3 mm. longa, badia, operculo minuto plano-convexo, peristomio *nullo*, sporis 20μ ad 28μ, laevibus, pellucidis.

Habitat: Zimbabwe, alt. 3,000 feet. (Sim, 8735, 8796, 8797). Khami Ruins alt. 5,000 feet (Sim, 8842).

A distinct species in the erect and almost symmetrical, narrow, long-necked, gymnostomous capsule; and the quite immarginate leaves, which are densely and regularly, obtusely serrate with the prominent usually hyaline marginal cells, one or two here and there still more prominent. An allied South African species, *F. gymnostoma* Dixon, is much more delicate, with smaller, shorter capsule, nerve ceasing below apex. *F. rottleri* is of similar habit, but has capsule mostly slightly curved, and leaves acuminate to a long, slender point.

Funaria hygrometrica (L.) Sibth.—Numerous localities.

BRYACEAE.

Brachymenium borgenianum Hampe.—On earth in shade, alt. 4,800 feet, and on clay bank, alt. 4,200 feet, Umtali (Eyles, 2765, 1737); Matopos, alt. 5,000 feet (Sim, 8845; Eyles, 936).

General distribution: South-West Africa, Transvaal, Usambara, Mauritius, Madagascar.

Brachymenium pulchrum (Hook).—Odzani R. Valley, Manica, Umtali (Teague, 164, comm. Sim); Zimbabwe, alt. 3,000 feet (Sim, 8733, 8734, 8781), mostly c.fr. Matopos (Sim, 8853; Eyles, 1114); Makoni, Timaru, on granite hill, alt. 6,500 feet (Dr. Nobbs, 1316, in herb. Eyles).

General distribution: Cape Province to East tropical Africa, Rodriguez.

B. campylotrichum (C.M.) Broth.—Zimbabwe, alt. 3,000 feet (Sim, 8814) St.

General distribution: Transvaal.

Brachymenium variabile Dixon, in Smithson. Misc. Colls. 69: 8: p.2 (1918).—Zimbabwe, alt. 3,000 feet (Sim, 8800, st., 8823, c.fr); Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8870, 8876, 8877), St.

No. 8823, the fruiting plant, agrees with the type from Uganda, in the vegetative characters, and in the pendulous or subpendulous capsules, but these are much more turgid than in the Uganda specimens. I can only look upon it, however, as a further aberration of this very variable species.

General distribution: Uganda.

Brachymenium rhodesiae sp. nov. Dixon.

Orthocarpus. Autoicum; flos ♂ discoideus, ramulo terminalis. Habitu *B. flexifolii* Schimp., *B. speirocladi* C.M., etc., sed foliis *multo flaccidioribus, siccis parum spiraliter torquatis, late oblongo-ovatis, nec spathulatis, perobtusis, perconcavis, marginibus perlate recurvis, subintegris, angustissime limbatis.* Seta 2 cm. alta vel paullo ultra, theca *erecta, crassiuscule fusiformis*, microstoma, operculo *breviter conico*, obtuso. Peristomii dentes anguste lanceolati, inferne saturate rubri, dorso transverse striolati, lamellis haud prominentibus; endostomii membrana adhaerens, processubus nulli? Spori 18μ ad 22μ.

Habitat: On granite hill, alt. 6,500 feet, Makoni (Eyles, 1317a); on dead wood in bush, Umtali, 4,000 feet (Eyles, 1730).

Differs from nearly all the allied autoicous species in the leaves soft and flaccid, scarcely spirally twisted when dry, not narrowed below nor spathulate, very concave and obtuse, with the margins widely recurved, the border very narrow and not cartilaginous, entire or nearly so. There seems some doubt as to the characters of *B. capitulatum* Mitt., but the leaves are described as of different texture and structure, and do not at all agree with those of the present plant. *B. revolutum* Broth. has very long seta and horizontal or pendulous capsules.

Anomobryum promontorii (C.M.) Dixon.—Victoria Falls, alt. 3,000 feet (Sim, 8937).

General distribution: Cape Province, Natal, Transvaal.

Bryum argenteum L.—I have this in more than a dozen gatherings from several localities. Some of them would be referable to *B. argyrotrichum* C.M., and *B. squarripilum* C.M., but these appear to me to intergrade too much with one another and with the type to be distinguished even as varieties.

I refer to var *australe* Rehm.—a well-marked and often very beautiful form—the following: Matopos, alt. 4,600 feet (Eyles, 935); Rhodes' Grave, alt. 5,000 feet (Sim, 8875); Zimbabwe, alt. 3,000 feet (Sim, 8787); and perhaps Sim, 8748 from Zimbabwe. Sim, 8741 (Zimbabwe, alt. 3,000 feet) is a form with julaceous, usually very obtuse leaves, sometimes chlorophyllose to the tip, similar to one I have described from Mt. Elgon (5).

General distribution: Cosmopolitan.

Bryum (Doliolidium) condensatum Hampe.—Victoria Falls (Wager, 909); Matopos, on ground, alt. 4,600 feet (Eyles, 938).

This species appears to be little known (it is omitted by Brotherus in the "Musci"), but rather distinct. I have it also from Stellenbosch (Wager, 626). It forms dense tufts, the stems and leaves usually reddish below, pale-green or reddish-green above; the leaves closely imbricate, and when dry erect and appressed, often enrolled, not very flexuose; the capsule when ripe turgid and barrel-shaped, corrugated at base as in *B. coronatum*, and like that with no tapering neck. Without the operculum it may be scarcely longer than wide.

General distribution: Cape Province.

Bryum rigidicuspis sp. nov. Dixon.

Doliolidium. Caespites densi, extensi, *subfaciliter dilabiles*, *lutescentes*, 1 cm. ad 2 cm. alti. Folia conferta, apicem versus paullo comata, parva, circa 1 mm. longa, late ovata, *breviter acuminata*, acuta, concava, marginibus plerumque revolutis, integris vel subdenticulatis; costa *valida*, *flava*, *per totam longitudinem subaequalis*, foliis caulinis *longe*, foliis innovationum *brevius excurrens*; *apice parum acuto*, integro vel dentibus paucis praedito. Areolatio breviuscula, e cellulis rhomboideis subpellucidis, 10μ ad 15μ latis, parietibus tenuibus, composita, marginem versus angustioribus linearibus, limbum male notatum instruentibus.

Dioicum videtur. Seta 1.5 cm. ad 2 cm. alta; theca subpendula, elliptico-piriformis, rubra 1.5 cm. longa, *collo distincto*, *brevissimo*, in setam *abrupte* desinente. Operculum conicum. Peristomium pallide rufescens, dentes densiuscule lamellosi, linea media *valde angulata*. Annulus latus, a cellulis *perangustis* compositas.

Habitat: Van Reenen Pass, Natal (Wager, 74); Zimbabwe, alt. 3,000 feet (Sim, 8790); Khami Ruins, alt. 5,000 feet (Sim, 8839, 8867). The Rhodesian plants are sterile and rather more robust than the Van Reenen fruiting plant, but the foliation quite

agrees and is characteristic. The nerve runs out into a stout yellowish cuspidate point or even arista, little narrower even at the extreme tip, and there usually ends with a few sharp teeth. The leaves are acute but not narrowly acuminate. The fruit is mostly immature, and it is not quite easy to determine the position in the genus; the only peristome in at all good condition has the endostome imperfect, and I have not been able to see well-developed cilia; the form of the capsule, however, and its bright red colour in the one or two nearly mature examples, seem to indicate that its position is in Doliolidium, with which the foliage quite agrees. The neck is scarcely narrower than the sporangium, somewhat corrugated, and passing quite abruptly into the seta in immature capsules, but the mature ones seem to show a tendency to taper very slightly and very shortly.

Bryum mundii C.M.—On rock ledge, Salisbury, alt. 5,000 feet (Eyles, 2426).

General distribution: Cape Province.

Bryum truncorum Bory.—Victoria Falls, alt. 3,000 feet (Sim, 8933).

General distribution: East African Islands, Cape Province, Transvaal, Australia, Tasmania, New Zealand.

I surmise that this species will be found to have a still wider distribution than the above (? *B. andicola* Hook., Syn. *B. lechleri* C.M., in South America); the Australian plant (*B. leptothecium* Tayl.) is certainly identical with Bory's plant.

Bryum truncorum Bory, nov. var. *pycnophyllum* Dixon.

Folia *haud rosulata, ubique aequaliter disposita, dense conferta*, parum patentia; habitu formarum minorum *B. wightii* Mitt. indici, sed foliis argute denticulatis. Caespites intus pallidi; folia plerumque breviora quam ea formae typicae.

Habitat: Zimbabwe, alt. 3,000 feet (Sim, 8737); Umtali, on rock in shade, alt. 5,000 feet (Eyles, 1725). Sterile.

Bryum syntrichioides C.M. in sched. Rehm. M.A.A. Nos. 228 and 557, belong to this species; 228, 228b, 557, 557b, 557c, to the type, 228c to this variety. The variety is very different in habit and leaf arrangement from the type; it exhibits little or none of the interruptedly comose leaf arrangement, and therefore forms a rather undesirable transition between the groups into which Brotherus divides the species of the section *Rosulata*.

The plant is in no way a *Rhodobryum*, under which genus Paris has placed *B. syntrichioides* C.M.

Rhodobryum commersonii (Schwaegr.) Par.—In mountain bush, Umtali, alt. 4,500 feet (Eyles, 1736) St.

There appears to be some confusion between this and *R. umbraculum* (Burch.) Par.; but, as I understand them, *R. umbraculum* has a more strongly bordered margin, often reddish,

with shorter, scarcely spinose teeth, while *R. commersonii* has the border less marked (? rarely or not reddish) and the teeth densely spinose, almost ciliate.

RHIZOGONIACEAE.

Rhizogonium spiniforme (L.) Bruch.—In wet forest, Inyanga, alt. 6,000 feet (Henkel, 2632, in herb. Eyles).

General distribution: Tropical and sub-tropical zones, generally.

BARTRAMIACEAE.

Bartramidula globosa (C.M.) Broth.—Matopos, alt. 5,000 feet (Eyles, 1050).

The specimen I have seen of this, sent me by Dr. Sim, was without fruit, but a single inflorescence was present, which, on dissection, proved to be synoicous. Apart from the dioicous inflorescence (fide Brotherus) and the warted capsule in *B. comosa* (Hpe. and C.M.) I find nothing to separate that species from the present; vegetatively the two appear to me to be identical.

General distribution: Cape Province, Natal.

Philonotis androgyna (Hampe) Jaeg.—Victoria Falls, alt. 3,000 feet (Sim, 8944).

General distribution: Cape Province, Natal, Transvaal.

Philonotis imbricatula (Mitt.)—In various forms and under several gatherings from Zimbabwe, Khami, the Matopos and Victoria Falls. All sterile.

I have not attempted to give the distribution (which is a very wide one) as the limits of the species are not well defined and it is doubtful whether it be distinct from several other described species that are at least closely allied. It was first described from the East Indies. I have a plant from Fiji which I cannot separate from it, and I doubt if *P. etessei* Broth. and Par. from New Caledonia can be kept distinct.

Philonotis laxissima (C.M.) Bry. jav.—Floating on lime-impregnated water of Sinoia Cave, Lomagundi, alt. 3,900 feet (Dr. Nobbs, 2547, in herb. Eyles) St. Dr. Nobbs wrote that it grew in round clusters, and free, with an accretion of lime below. It strongly repelled the water when submerged. It is a curious and very delicate growth, much encrusted with (?) sulphate of lime. It agrees very well with other specimens of *P. laxissima* which I have from Africa and elsewhere, and though under the abnormal circumstances of growth its specific characters may well have become masked, I think it may safely be referred here.

General distribution: Assam, East Indies, New Hebrides, Madagascar, Natal, Egypt.

Philonotis laeviuscula sp. nov. Dixon.

Philonotula. Sat. robusta, circa 5 cm. alta, flavo-viridis.

Folia *saepius seriata falcato-secunda*, lanceolata, haud plicata, *sicca leniter flexuosa*, marginibus, *planis vel subplanis*, conferte denticulatis; costa validiuscula, in aristam *sat validam* denticulatam *haud longe* excurrens. Cellulae *omnes sat laxae*, pellucidae, leniter papillosae, basin versus laxiores, longiores.

Autoica. Flos ♂ gemmiformis, *prope perichaetium situs*, turgidus, antheridiis atque paraphysibus clavatis multis. Florem ♂ aliquando in cauli proprio terminalem, inde ob innomationem singulam lateralem factum vidi. Bracteae perigoniales internae e basi lata concava abrupte rigide subulatae. Seta 1 cm. ad 1.5 cm. alta, tenuis. Theca subglobosa, microstoma, nutans, *leptodermica*, *sicca laevis vel leniter tantum plicata*, exothecii cellulae laxae, hexagonae vel subquadratae, parietibus firmis *nec tamen incrassatis*. Peristomium *imperfectum*, nunc rudimentarium, nunc e dentibus brevibus, pallide rubris, irregularibus; endostomium male evolutum, e processubus rudimentariis instructum.

Habitat: Odzani Valley, Manica district, Umtali, Eastern Rhodesia (A. J. Teague, 253).

A very distinct species, closely allied in the foliation and inflorescence to the widely spread Asiatic species *P. falcata* (Hook); but differing in the thin-walled capsule, smooth, or lightly plicate only when dry at times, and the peristome rudimentary, or at least ill developed.

POLYTRICHACEAE.

Catharinea androgyna C.M.—Mt. Pene, alt. 7,000 feet, Swynnerton (Eyles, 6021); Eyles (8).

General distribution: Cape Province, Natal, Transvaal, Zululand.

Pogonatum capense C.M.—Victoria Falls, alt. 3,000 feet (Sim, 8932).

General distribution: Cape Province, Transvaal, Natal.

Polytrichum commune L. var. *trichodes* (Rehm.) Dixon comb. nov. Syn. *Polytrichum trichodes* Rehm. e C.M. in Hedwig., 38, p. 63 (1899); Victoria Falls, Jas. Sim (Sim, 7393) St.; Matopos, alt. 5,000 feet (Eyles, 1039) St.

The principal point about this plant is the long arista of the leaf, formed by the excurrence of the nerve, in a terete, spinulose hair, usually of 1 mm. to 2 mm. in length. It it quite clearly only a derivative of *P. commune*, and it is probably distributed throughout some considerable part of the area of that species, and the above name may be found to be antedated by some earlier specific one.

The type of *P. commune* also occurs in Rhodesia, probably not very rarely; but I have it only in one gathering, viz., Inyanga, alt. 6,000 feet, Dr. Nobbs (Eyles, 1360).

Polytrichum commune var. *minus* Weis.—Zimbabwe, alt. 3,000 feet (Sim, 8792); Khami Ruins, alt. 5,000 feet (Sim, 8844).

General distribution (of variety): Europe generally, Atlantic Islands, South Africa generally, Madagascar, north temperate North America, New Zealand.

ERPODIACEAE.

Aulacopilum trichophyllum Aongstr.—Acropolis, Zimbabwe, alt. 3,250 feet (Sim, 8816).

General distribution: Cape Province, Transvaal, Zululand.

This specimen was growing on stones; a very unusual habitat for such a characteristically corticolous plant.

Erpodium hanningtonii Mitt.—Zimbabwe, alt. 3,000 feet (Sim, 8801); on rock, Matopos (Wager, 899); Victoria Falls (Wager, 907); rarely found elsewhere than on trees.

General distribution: Transvaal, East tropical Africa.

Erpodium distichum Dixon and Wager.—On tree trunk in partial shade, Lomagundi, alt. 3,500 feet (Eyles, 2702).

General distribution: Transvaal, Natal, Portuguese East Africa.

Braunia secunda (Hook.) B. and S.—In numerous localities. Frequent about the Zimbabwe Ruins; a distinctly xerophytic type. Granite boulders, Bulawayo (Sadler, 383, in herb. G. Webster); Makoni (Eyles, 835); Rhodes' Grave, Matopos, alt. 5,000 feet (Sim, 8871), etc.; Salisbury, alt. 4,900 feet (Eyles, 1572).

Several of the gatherings are referable to the forma *longipila*, one from Macheke, on granite rock, alt. 5,000 feet (Eyles, 1993) being a very extreme condition; some of the branches having the leaf acumen hyaline quite as in *Hedwigia albicans*. Many of the gatherings were in fruit. "*Hypnum sp.*" Eyles [8] is this species (Eyles, 1026).

General distribution: South and Central Africa, India, Central America.

Braunia peristomata sp. nov. Dixon.

Habitu ei *B. secundae* et *B. elliotii* sat similis, sed ramis longioribus, siccis *teretibus subnitidis*, *leniter curvatis*, foliis *arcte imbricatis apicibus erectis haud patulis*. Seta vix 1 cm. longa; perichaetium *circa dimidiam partem longitudinis setae aequans*, *arcte convolutum*, theca *breviter elliptica*, microstoma, operculo breviuscule curvirostrato. Peristomium *bene evolutum*, *simplex* e dentibus 16 instructum, pallidis, lanceolatis, superne parum angustatis, subobtusis, saepius per paria cohaerentibus, lamellis remotiusculis, intus vix prominentibus; dentes ubique nisi articulationes 2 ad 3 infimae (ibique laeves vel parce papillosae) dense papillosi.

Habitat: Great Zimbabwe Temple Ruins, on tree, alt. 3,000 feet (Sim, 8750, 8778, 8793, 8809); Fort Victoria, alt. 4,000 feet (Sim, 8843).

The long, curved, terete branches, having the leaves very regularly and closely imbricate, not spreading, when dry, gives them a characteristic appearance, but the main character is the well developed peristome, unique in the sub-family, and—with the *single exception of Cleistostoma ambiguum*—in the family of Hedwigiaceae. The widely elliptic capsule and the perichaetium reaching half-way up the seta, are also marked characters.

NECKERACEAE.

Papillaria africana (C.M.) Jaeg.—Zimbabwe, alt. 3,000 feet (Sim, 8791, 8795) St.; Umtali, in trees in mountain bush, alt. 5,000 feet (Eyles, 1721) St.

General distribution: South Africa generally, East tropical Africa, Madagascar.

Trachypodopsis serrulata (P. Beauv.) Fleischer.—In wet forest, Inyanga, alt. 6,000 feet (Henkel. 2630, in herb Eyles) St.

General distribution: Fernando Po, East tropical Africa, Comores, Madagascar, Bourbon. The present record is a rather interesting extension of its range.

Calyptothecium brotheri (Par.) Dixon comb. nov.

Syn. *Neckera brotheri* Par. Ind. Ed. I, Suppl. p. 254 (1900). *Calyptothecium subacutifolium* Broth. in Engl. Bot. Jahrb., 24 (1897), p. 254; (*nec C. subacutifolium* (Geh. and Hampe) Broth.; *Neckera subacutifoli* Geh. and Hampe in "Flora," 1881, p. 379)); *Calyptothecium beyrichii* Broth. in Engl. and Prantl. Pflanzenfam., Musci, II, 839 (1906).

Victoria Falls, alt. 3,000 feet (Sim, 8910, 8922; Wager, 914); Victoria Falls, Palm Grove, alt. 2,500 feet (Sim, 8913); Victoria Falls, Palm Kloof, on Phoenix (Brunnthaler), Brotherus (2).

The synonymy above appears rather confusing, but is really simple. Brotherus in 1897 described a plant collected by Beyrich in Pondoland as *Calyptothecium subacutifolium* sp. nov., having overlooked the Brazilian species *Neckera subacutifolia* Geh. and Hampe, which belongs to Calyptothecium. Later, in the "Musci" and elsewhere, he has replaced this name by *C. beyrichii* Broth. But in the meantime Paris in the Sppl. to Index, ed. I, had given the African plant the name *Neckera brotheri*; and this name antedates *C. Beyrichii* by some years. The plant must therefore stand as I have given it above, so long as its specific rank is maintained. The specimens, however, that I have seen from the localities cited, and one or two other allied plants from South Africa, vary considerably, and I am strongly of opinion that the plant of continental Africa will have to be united with the Bourbon *C. acutifolium* (Brid). *Neckera pseudo-crispa* C.M. from Van Reenen is certainly identical with *C. acutifolium*, and this greatly reduces the probability of the present plant being anything more than a raceform.

General distribution: Pondoland.

Porotrichum comorense Hampe.—In wet forest, Inyanga, alt. 6,000 feet (Henkel, 2629, 2636, in herb. Eyles). Cum setis.

General distribution: East African Islands generally, Usambara, Belgian Congo, Fernando Po.

Thamnium pennaeforme (Hornsch.) Kindb.—Wet forest, Inyanga, alt. 6,000 feet (Henkel, 2628, in herb. Eyles) St.

General distribution: South Africa generally, and in addition that of *Porotrichum comorense*. I am greatly of the opinion that the latter is only a form of this highly variable species.

ENTODONTACEAE.

Entodon dregeanus (Hornsch.) C.M.—Zimbabwe, alt. 3,000 feet (Sim, 8758); Umtali, rock in bush, alt. 4,200 feet (Eyles, 1731), and tree-trunk, alt. 4,000 feet (Eyles, 1734).

General distribution: Cape Province, Transvaal, Natal, Zululand, East tropical Africa, Bourbon, Belgian Congo.

Entodon cymbifolius Wager and Dixon.—Zimbabwe, alt. 3,000 feet (Sim, 8786).

General distribution: Transvaal.

Erythrodontium sp.—Zimbabwe, alt. 3,000 feet (Sim, 8776). A very small quantity of a sterile species which appears certainly different from *E. subjulaceum* (C.M.) Par., the common species of Central Africa; it is more slender, glossy, closely pinnately branched with short branches under 1 cm. in length; the leaves when dry closely applied and julaceous, with the points scarcely spreading; chlorophyllose, much softer in texture than in that species, with the upper cells very narrow and small, the alar filling most of the base, very numerous, thin, hyaline or pellucid. *E. engleri* Broth. has similar leaf structure, but is far more robust.

Trachyphyllum gastrodes (Welw. and Duby) Gepp.—Zimbabwe, alt. 3,000 feet (Sim, 8756b, 8760); Khami Ruins, alt. 5,000 feet (Sim, 8840); Rhodes' Grave, alt. 5,000 feet (Sim, 8872b, 8873, 8876 p.p.). All sterile.

General distribution: Angola, Transvaal.

Trachyphyllum maximum Dixon sp. nov.

Stirps pro genere *robustus;* caules 4 cm. ad 5 cm. longi, haud, ut videtur, intricati, superne virides, inferne ochracei; *sat regulariter confertiuscule pinnati*, ramis circa 0.5 cm. longis, turgidiusculis siccitate gracilibus, teretibus. Folia caulina 0.8 mm. ad 1 mm. longa *subdeltoidea,* anguste acuminata; folia ramea paullo minora, suborbicularia, brevius acuminata; omnia concava, marginibus planis, integris, costa brevissima, basi latiuscula, saepius gemella, male notata. Cellulae superiores elongate rhomboideae, sigmoideae, dorso spiculosae, medium folium versus angustiores longiores, basilares (nisi juxtacostales) sensim breviores latiores, alaribus multis, *pellucidis dimidiam partem fere basis occupantibus*, *marginalibus saepe transverse ellipticis.*

Fructus ignotus.

Habitat: Makoni (Dr. Nobbs, 1317b, in herb Eyles).

This is, I think, the most robust species of the genus hitherto described. *T. borgenii* (C.M.) from Madagascar comes near it (and if, as Cardot suggests, that should prove to be a robust form of *T. fabronioides*, it is probable that this may also have to be reduced), but is more slender, with laxer branch leaves, and hence less turgid branches. *T. dilatatum* Ren. has the stem leaves very broad, wider in fact than long, which is not the case here.

Stereophyllum odontocalyx (C.M.) Jaeg.—Tree Trunk, Mazoe, Tatagura Valley, alt. 4,300 feet (Eyles, 652, 713); Umtali, alt. 4,000 feet (Eyles, 1743); Great Zimbabwe Temple Ruins, alt. 3,000 feet (Sim, 8755); Victoria Falls, alt. 3,000 feet (Sim, 8888, 8889, 8908, 8912, 8918, 8921, 8923; Wager, 913; Eyles, 1304). All fruiting.

Several of the Victoria Falls gatherings show a dark green, robust, luxuriant form with long stems and large leaves, long seta (to 2 cm.), and usually with fewer capsules—probably a hygromorph.

General distribution: Cape Province, Transvaal, Natal, German East Africa, Uganda.

Fabroniaceae.

Fabronia abyssinica C.M.—On earth between rock and tree, Salisbury, alt. 4,900 feet (Eyles, 684a); Bulawayo, alt. 4,500 feet (Eyles, 1053); Zimbabwe, alt. 3,000 feet (Sim, 8762, 8769, 8803, 8804); Matopos, alt. 5,000 feet (Sim, 8855); Victoria Falls, alt. 3,000 feet (Wager, 905). All, or nearly all, fruiting.

No. 8804 is a lax, dark green form, with short hair-points, which might be a distinct species, but it does not seem to agree quite with any of the other described species, and is probably a shade form of this.

General distribution: South and East Africa generally.

Fabronia perciliata C.M.— Rua R., near Salisbury, alt. 5,000 feet (Eyles, 1323); Victoria Falls, alt. 3,000 feet (Sim, 8907b).

I have received, by the kindness of the authorities of the Berlin Museum, an original specimen of C. Mueller's species, which shows that it is by no means one of the species with highly ciliate leaves, as the name and to some extent the description would imply. It differs little indeed from the common forms of *F. abyssinica*, so little indeed that I doubt much if it be really distinct; but I retain it temporarily. The South African species of this genus need carefully revising.

General distribution: Cape Province, Natal, Transvaal.

Fabronia angolensis Welw. and Duby.—Zimbabwe, alt. 3,000 feet (Sim, 8815); Salisbury, alt. 4,900 feet, on tree trunk; and on vertical granite in shade (Eyles, 1573, 1575). The latter has short points, and may be referred to var. acuminata Gepp.

General distribution: Angola, Uganda, Cape Province. (The distribution may probably have to be revised on a better understanding of the South African plants.)

Fabronia pilifera Hornsch.—On "Beefwood" tree, Salisbury, alt. 4,900 feet (Eyles, 1447).

General distribution: Cape Province, Transvaal.

Fabronia leikipiae C.M.—Zimbabwe, alt. 3,000 feet (Sim, 8767, 8783, ? 8821).

The quite entire leaves, abruptly hair-pointed, are very distinct. No. 8821 is somewhat doubtful. The leaves are usually entire, but may have a few teeth at base of acumen and elsewhere.

General distribution: East tropical Africa (Aberdare Mts.); German East Africa, Cape Province.

Fabronia victoriae **sp. nov. Dixon.**

E tenerioribus generis; caulibus dense intertextis, brevibus, viridibus; folia caulina *anguste ovata, sensim acuminata, vix pilifera* marginibus *fortiter ciliolatis;* ramea *late ovata*, acuminata *haud longe pilifera*, irregulariter, nunc breviter nunc longe ciliolata, omnia *subecostata;* cellulae pellucidae, latiusculae, chlorophyllosae, alares *paucae*, subquadratae.

Theca minuta, ovata, sicca suburceolata, brevicollis.

Habitat: Victoria Falls, alt. 3,000 feet (Sim, 8943).

Very distinct in the highly ciliate teeth of the leaf margin, as in no other African species. *F. perciliata* C.M. has the teeth occasionally, but not often ciliate, and in addition has denser much more acuminate leaves with long hair-points.

HYPOPTERYGIACEAE.

Hypopterygium laricinum (Hook.) Brid.—Wet forest, Inyanga, alt. 6,000 feet (Henkel, 2634, in herb Eyles) St.

General distribution: Fernando Po, East and West tropical Africa, Natal, Cape Province, Madagascar.

RHACOPILACEAE.

Rhacopilum capense C.M.—Victoria Falls, alt. 3,000 feet. (Brunnthaler; Sim, 8892, 8911; Eyles, 112;* Wager, 906). Mostly sterile. Zimbabwe Ruins, alt. 3,000 feet (Sim, 8757) c.fr.; Umtali, rock in bush, alt. 4,200 feet (Eyles, 1732).

General distribution: Southern and Central Africa generally.

LESKEACEAE.

Lindbergia pseudoleskeoides Dixon.—Bulawayo (Sadler, 317, in herb. G. Webster); Zimbabwe, alt. 3,000 feet (Sim, 8744,

* This is the "Rhacopilum sp." of Eyles [8].

7846, 8752 p.p., 8824); Matopos, alt. 5,000 feet (Sim, 8848). Nos. 8824, 8848 have the areolation a little more distinct, and the nerve a little narrower than in the type.

General distribution: Transvaal.

Lindbergia patentifolia Dixon.—Zimbabwe, alt. 3,000 feet (Sim, 8774) c.fr. The fruit has not been observed. It does not appear to differ materially from that of the other South African species.

General distribution: Uganda.

Pseudoleskea claviramea (C.M.) C.M.—Zimbabwe, alt, 3,000 feet (Sim, 8759, 8794).

General distribution: Cape Province, Transvaal, Orange River Colony, Zululand, East tropical Africa, Madagascar.

Pseudoleskea leskeoides Schimp.—Zimbabwe, alt. 3,000 feet (Sim, 8756, 8775). I find it increasingly difficult to separate this from *P. claviramea*.

General distribution: Cape Province, Natal, Transvaal.

Rauia abbreviata (Broth.) Broth.—Zimbabwe, alt. 3,000 feet (Sim, 8774b); Khami Ruins, 5,000 feet (Sim, 8863).

General distribution: Shire Highlands, German East Africa.

Thuidium versicolor (Hornsch.) Schimp.—Victoria Falls, on stems of trees (Brunnthaler) (2).

General distribution: Cape Province, Natal, Zululand, East tropical Africa.

Thuidium borbonicum Besch.—Victoria Falls, alt. 3,000 feet. (Cheeseman, September, 1905, comm. M. B. Slater; Sim, 8893; Miss Farquhar, 23; Wager, 908) St.

General distribution: Natal, Uganda, Bourbon.

Hypnaceae.

Drepanocladus sparsus C.M.—Victoria Falls (Wager, 902) St.; Makoni, alt. 4,700 feet, on earth by running water (Eyles, 787) St.

General distribution: Cape Province, Orange River Colony.

["*Amblystegium varium* Lindb.—On stones by stream, Mazoe, alt. 4,600 feet (Eyles, 402.)" (8) This proves, from an original specimen sent me by Dr. Sim, to be *Isopterygium aquaticum* sp. nov.; v. infra.]

Microthamnium pseudo-reptans (C.M.) Par.

Syn. *Hypnum glabrifolium* C.M. in "Flora," 1890, p. 496. *Microthamnium glabrifolium* "Par. Ind.," p. 809.

M. glabrifolium is entirely indistinguishable from *M. pseudo-reptans*. C. Mueller suggests no differences in his description, while he acknowledges the resemblance when he asks whether the plant referred by Mitten to *M. pseudo-reptans* may not be his *M. glabrifolium*.

Inyanga (Henkel, 2625, in herb. Eyles).

General distribution: Cape Province, Natal, Transvaal.

Ectropothecium regulare (Brid.) Jaeg.—Umtali, alt. 4,300 feet (Eyles, 1740) St.

General distribution: East African Islands, Cameroons.

Ectropothecium perrotii Ren. and Card.—Wet forest, Inyanga, alt. 6,000 feet (Henkel, 2623, in herb. Eyles); Victoria Falls, alt. 3,000 feet (Sim, 8900; Wager, 903). All sterile. Very near *E. regulare*, and perhaps only a form or variety of that species.

General distribution: Madagascar.

Acanthocladium trichocolea (C.M.) Broth.—Wet forest, Inyanga, alt. 6,000 feet (Henkel, 2623c, 2625 p.p., 2637, in herb. Eyles) St.

General distribution: East tropical Africa.

Isopterygium aquaticum sp. nov. Dixon.

Submersum, caespites extensos, *molles*, flaccidos, superne *olivaceos*, *inferne nigrescentes*, formans. Caulis distanter irregulariter subpinnatus, *percomplanatus*, tener, sed robustiusculus. Folia remotiuscula, *percomplanata*, *late patentia sicca vix mutata*, ovata, *haud acuminata*, *obtusa vel subacuta*, concava, subecostata, marginibus planis, *integerrimis*. Cellulae superiores peranguste lineares, parietibus tenuibus basin versus vix mutatae, infimae 1 ad 2 seriebus multo laxiores, *ovatae*, *pellucidae*. Alares, nisi saepe cellula singula inflata ad angulum decurrente, vix distinctae.

Autoicum. Seta plus minusve 1 cm. ad 1.25 cm. alta crassiuscula. Perichaetii bracteae *suberecti*, e basi latiore cito in acumen subulatum *strictiusculum*, *integrum* angustati, *saepe tamen dente singulo grossiusculo hic illic incisi*. Theca parva, 1 mm. longa *pendula*, turgide elliptica, collo brevi distincto paullo curvato; exothecii cellulae laxiusculae, latae.

Under running water, Makoni, alt. 4,700 feet (Eyles, 780).

Quite marked in the aquatic habit, soft texture, leaves spreading widely distichously, scarcely altered when dry, not acuminate, subacute only and often quite obtuse, and entire. The capsule is pendulous and almost Ectropothecioid in character, but (in the only two seen) is usually slightly curved and asymmetric.

Plagiothecium rhynchostegioides C.M..—Wet soil by stream, Matopos, alt. 4,600 feet (Eyles, 2538, 2542).

General distribution: Cape Province.

Rhaphidostegium krakakammae (C.M.) Jaeg.—Tree trunk Inyanga, alt. 6,000 feet (Dr. Nobbs, 1359, in herb. Eyles).

General distribution: Probably distributed throughout South Africa.

Rhaphidostegium caespitosum (Sw.) Jaeg.—Tree trunk, Salisbury, alt. 4,900 feet (Eyles, 683). This is the remarkable form with wide, obtuse, secund leaves, and the branches almost circinately incurved when dry, described by Brotherus as *Pterogoniella stuhlmannii.* It is, however, connected with ordinary forms of *R. caespitosum* by intermediate stages.

General distribution: Southern subtropical and temperate zones generally.

Rhaphidostegium brachycarpum (Hampe) Jaeg.—Zimbabwe, alt. 3,000 feet (Sim, 8825).

General distribution: Cape Province, Natal, Transvaal, Zululand, Portuguese Gaza Land.

Brachytheciaceae.

Brachythecium implicatum (Hornsch.) Jaeg.—Matopos, alt. 5,000 feet (Sim, 8854); Umtali, on rock in shade, alt. 5,000 feet (Eyles, 1722) St.

General distribution: Cape Province, Transvaal, Natal, Zululand, East tropical Africa.

Rhynchostegium brachypterum (Hornsch.) Jaeg.—Matopos (Wager, 891).

General distribution: Cape Province, Natal.

MOSSES FROM PORTUGUESE GAZA LAND.

The small collection of mosses made by the Rev. H. A. Junod, described below, supplemented by a further small collection made by Dr. Sim in almost the same localities, are from a small district in the southern portion of Portuguese Gaza Land, about 25° .2′ S. Lat., and 32° .5′ E. Long., and approximately thirty miles from the Transvaal border, equidistant from that on the west and the sea coast on the east; principally from the valley of the Incomati River. For the most part the district is a sandy veld, and mosses do not occur except by the river side or on trees and rocks in shaded tree-clad creeks, etc. These spots are very isolated, and even there the mosses are very few; but the two collections, consisting in all of about seventeen gatherings, contained some quite interesting things.

The ecological conditions in the district are governed greatly by the Incomati River, a large river rising in the Transvaal, skirting Swaziland, and after a long detour northwards, returning south-eastwards to join the sea near Lourenço Marques. At the time of Dr. Sim's visit to the district, it was about 150 yards wide where he crossed it; but frequently, owing to rains in the mountainous country which it traverses in passing from the Transvaal, these low-lying tracts are flooded to a wide extent even when the weather is locally dry. Though south of the tropic, the climate is usually hot, and the vegetation corresponds much more closely with the xerophilous tropical flora further north than with the

adjoining Natal and Zululand floras. The subsoil varies; the rock at Magude is all lava, while farther up, at Hellet's Concession, where Dr. Sim collected, it is limestone, and this variation no doubt accounts for the disproportionally large number of species compared with the number of gatherings made.

Dicranaceae.

Trematodon aequicollis Ren. and Card.—Antioka (Junod, 322), Chicumbane (Junod, 333).

These agree exactly with the description and figures of *T. aequicollis*, as given by Roth, differing from *T. divaricatus* B. and S. in the narrower nerve and denticulate subula of the leaves; from the other peristomate African species in the peristome teeth mostly split through their whole length, not united above.

General distribution: Belgian Congo.

Campylopus clavatus (R. Br.) Jaeg.—Magude (Junod, 334) St.

General distribution: Australasia, St. Paul Island, Cape Province, Transvaal.

Fissidentaceae.

Fissidens erosulus (C.M.) Par.—Magude (Sim, 8995).

General distribution: Niam-Niam, Uganda, Southern Rhodesia.

Fissidens rotundatus sp. nov. Dixon.

Crispidium. E gracillimis generis; caules 2 mm. ad 3 mm. *tantum* longi, pulcherrime frondosi, plurijugi, complanati, *oblongi, obtusi*, pervirides; foliis siccis fortiter falcato-decurvatis, caespites parvos densos instruentes. Folia conferta, *patentia*, percomplanata, 0.5 mm. longa, *breviter oblonga, superne nullo modo angustata, rotundato-obtusa vel obtusissime apiculata;* marginibus ubique minute sed distincte crenulatis; lamina vaginans paullo ultra medium folii producta, *apud costam terminata, ibidemque rotundata, nec acuta;* lamina dorsalis ad folii basin attingens, ibidemque abrupte desinens. Costa *tenuis, ubique, praecipue superne, pellucida, perlonge sub apice dissoluta.* Cellulae superiores obscurae, opacae, minutae, 4μ ad 7μ latae, minute densissime papillosae, parietibus tenuibus pellucidis.

Habitat: Shirindjen (Junod, 329a).

A very pretty and quite distinct little species, with gracefully frondose stems, short oblong leaves generally very widely rotundate above and very obtuse, the vaginant lamina ending in a pointed apex and close to the nerve, and the highly pellucid nerve ceasing far below the apex, sometimes reaching only about 3/4ths or 4/5ths of the length of the leaf.

Since the above was drawn up I have received the same species from Mazoe, Southern Rhodesia, coll. Eyles (v. supra, p. 307), in fruit. The seta is very short, scarcely more than 1 mm.; cap-

sule very small, erect, elliptic, rather wide-mouthed when dry, thin-walled, having the exothecium cells wide and isodiametric, with very thin walls. Peristome teeth very highly lamellate, or cristate, within.

Pottiaceae.

Hymenostomum eurybasis sp. nov. Dixon.

A speciebus africanis affinibus (*H. socotranum*, *Weisia viridula*, etc.) differt foliis siccis *laxe incurvo-flexuosis*, nec fortiter incurvis, costa tenuiore, siccitate dorso *haud nitida*, apice plerumque obtuso vel brevissime apiculato, marginibus *late* involutis *basi folii plus minusve distincte, aliquando abrupte dilatata*, hyalina. Seta circa 4 mm. alta, tenuis, flava, theca aurantiaca, sicca sub ore leniter constricta; peristomium nullum, orificium principio hymenio clausum.

Habitat: On earth, Matopos, Mchelele Valley, alt. 4,700 feet (Eyles, 940, 941); (v. *supra*). Hellet's Concession, Magude, alt. 500 feet (Sim, 8989).

Stems rather taller than in most of the allied species, from which it is not widely distinct, but the characters italicized above make it difficult to unite it with any of those described. The apex of the leaf is generally quite obtuse and subcucullate, with the margins strongly incurved; and the leaves not shining at back and not strongly crisped when dry seem marked features, though these characters are to some extent shared by *H. socotranum* Mitt.

Hyophila atrovirens (C.M.) Jaeg.—On lime, Hellet's Concession, Magude (Sim, 8991, 8992, 8994).

Hyophila Zeyheri (Hampe) Jaeg.—Hellet's Concession, Magude, on lime, alt. 500 feet (Sim, 8993).

Funariaceae.

Micropoma niloticum (Del.) Lindb.—On soil, Antioka (Junod, 323).

A most interesting discovery; the plant has, so far as I know, not been recorded elsewhere than from its original gathering in Lower Egypt early in the nineteenth century. The present plant agrees exactly with the Egyptian specimens at Kew, except in being a slightly smaller form.

A second species, *M. bukobense*, has been described by Brotherus from Central Africa, differing from *M. niloticum*—apparently very slightly—in the form of the leaves.

Physcomitrium spathulatum C.M.—Shirindjen, at low altitudes (Junod, 332).

General distribution: Cape Province, Natal, Transvaal, Southern Rhodesia.

I was at first inclined to separate this plant as *P. poculiforme* Mitt. MS. in herb. Mitten's specimen from Port Natal agrees

with *P. spathulatum* in all respects except that the lid is furnished with a short erect blunt beak, or apiculus, while that of *P. spathulatum* is described as hemispherical; and some of the South African plants certainly have a lid without any apiculus. However among my gatherings I find so much variety in the lid, from being hemispherical when moist and slightly apiculate when dry, through many degrees of rostellation to that of Mitten's specimen that I think the distinction cannot be maintained. Mitten, I should add, does not describe his *P. poculiforme*, and I have no reason to suppose that he intended to separate it on the ground of its lid, indeed the name distinctly implies that it was not so; it is more probable that he was not acquainted with C. Mueller's species.

ERPODIACEAE.

Erpodium distichum Wager and Dixon.—Hellet's Concession, Magude, alt. 500 feet (Sim, 8988).

HYPNACAE.

Ectropothecium brevisetum sp. nov. Dixon.

E minutissimis generis. Coticola; caules *densissime intertexti, perbreves*, irregulariter subpinnatim ramosi, ramis brevissimis; *laete virides;* folia *percomplanata*, late patentia, sicca vix mutata, parva, vix 1 mm. longa, ovato-lanceolata, *breviter anguste acuminata, integerrima*, ecostata; cellulae angustissime lineares, laevissimae, basin versus parum latiores, ad angulos *paucae subquadratae, laxiusculae, chlorophyllosae.*

Autoicum. Folia perichaetialia caulinis similia sed longius, angustius acuminata, *erecta*, integra, vel subdenticulata. Seta *perbrevis*, 4 mm. ad 6 mm. alta, tenuissima, *pallida;* theca pendula vel subpendula, *minutissima*, 0.75 mm. longa, pallide fusca, turgide elliptica, basi in setam abrupte contracta, operculo *pallido*, conico-rostellato. Peristomii dentes flavidi, inferne pulchre transverse striolati, superne papillosi. Spori circa 14μ.

Habitat: Shirindjen, at low altitude (Junod, 331).

A pretty little species, very near my *E. dummeri* from Uganda (5), but of a bright green, with more narrowly acuminate leaves, narrower cells, and a shorter seta. The very flat, smooth tufts are marked.

Rhaphidostegium brachycarpum (Hampe) Jaeg.—Shirindjen (Junod, 328, 328b, 330).

REFERENCES.

(1) BROTHERUS, V. F.—"Musci," *Wissensch. Ergebn. der Deutschen Zentral-Afrika-Exped.*, 1907-1908, *unter Fuehrung Adolf Friedrichs, Herzogs zu Mecklenburg*, Bd. II, Botanik.

(2) BROTHERUS, V. F.—"Ergebn, einer Botanisch. Forschungsreise nach Deutsch-Ostafrika und Sudafrika (Kapland, Natal und Rhodesia); Musci," *Denkschr. der Math.-Nat. K. K. Akad., Wien*, Bd. 88 (1913).

(3) BRYHN, N.—"Bryophyta nonnulla in Zululand collecta." *Videnskapsselskapets Forh.*, 1911, No. 4. Kristiania (1911).

(4) DIXON, H. N.—"The Mosses collected by the Smithsonian African Exped., 1909-1910." *Smithson. Miscell. Colls.*, 69:2:(1918).

(5) DIXON, H. N.—"Uganda Mosses collected by R. Dummer and others." *Smithson. Miscell. Colls.*, 69:8:(1918).

(6) DIXON, H. N.—"Reports upon two collections of Mosses from Brit. East Africa." *Smithson. Miscell. Colls.*, 72:3:(1920).

(7) DIXON, H. N.—"New and interesting South African Mosses." *Trans. Roy. Soc. S. Afr.*, VIII, pp. 179-224 (1920).

(8) EYLES, F.—"Records of plants collected in Southern Rhodesia; Mosses." *Trans. Roy. Soc. S. Afr.*, V, p. 278 (1916).

(9) WAGER, H. A.—"A Check List of the Mosses of South Africa." Pretoria (1917).

THE POTENCY OF PEPPER TREE POLLEN AS A CAUSE OF HAY FEVER.

BY

GEORGE POTTS, B.Sc., Ph.D.

Professor of Botany, Grey University College, Bloemfontein.

Read July 15, 1921.

Bloemfontein and certain other towns of the drier inland region of South Africa suffer annually in the early summer from a very virulent form of hay fever, which occurs on such a scale as to justify being termed epidemic. A preliminary account (1919) of an investigation into the cause of these epidemics appeared in Vol. XV of THE SOUTH AFRICAN JOURNAL OF SCIENCE, page 525. It was there stated that the disorder is commonly attributed to the pepper tree (*Schinus molle*), a member of the family Anacardiaceæ, and indigenous to South America. This plant is grown as a street tree in nearly all South African towns, but in especially large numbers in many of the towns and villages of the Karroo itself and neighbouring karroid regions. It was shown that this tree has very sticky pollen, that its flowers produce nectar freely and are visited by insects, and that it has in every respect typical insect-pollinated flowers. According to all past experience such a plant therefore should not cause hay fever in nature.

Since the preliminary report was written, the investigation has been continued along several lines, including a determination of the pollens floating in the air. The present report is confined to some experiments, designed to test the power of pepper tree pollen to cause the disorder; but it is hoped to publish the complete results of the investigation at an early date.

The method adopted in the experiments was what is known as the cutaneous reaction, and consists in scarifying the skin (as in ordinary vaccination) and applying to it the pollen or pollen extract to be tested. In the case of a patient susceptible to the particular pollen used, the result is a local reddening and swelling, the extent of which is proportional to the patient's degree of susceptibility; and if the patient is not susceptible to that particular kind of pollen there is no reaction. The test, which causes little or no inconvenience to the patient, depends upon the fact that the scratching of the outer layers of the skin enables the pollen to come in contact with the sensitive underlying tissue where it causes irritation, just as it does in nature when carried by wind into contact with the delicate membranes of the nose, throat and eyes.

Particulars of the tests, which were performed at Bloemfontein on March 9, 1921, are given in the following table:—

Patient.		Susceptibility to Epidemic Hay-Fever in Bloemfontein.	Reaction to the following when applied to the scarified skin.			
No.	Name.		Neat Pepper Tree Pollen.	Control Solution (Normal Saline or Sodium Carbonate).	Saline Extract of Pepper Tree Pollen.	Emulsion of Oil from outside of Pollen in Sodium Carbonate.
1	Mrs. W.	Susceptible	Strong	Nil.	Very mild	Nil.
2	Mrs. Gl.	,,	Strong	Very mild	,,	Mild
3	Mrs. du T.	,,	Very Strong	Moderate	,,	Very mild
4	Mrs. H.	,,	Strong	Nil.	Nil.	,,
5	Mrs. R. C.	,,	Strong	,,	,,	Nil.
6	Mr. C.	,,	Very Strong	,,	,,	,,
7	Mr. R.	,,	Very Strong	,,	Very mild	,,
8	Mr. D.	,,	Very Strong	,,	Nil.	,,
9	Mrs. Gn.	,,	Strong	,,	,,	Mild
10	Mr. Gl.	Not susceptible	Nil.	,,	,,	Nil.
11	Mr. R. C.	,,	,,	,,	,,	,,
12	Mr. Gb.	,,	,,	,,	,,	,,
13	Mr. M.	,,	,,	,,	,,	,,
14	Mr. P.	,,	,,	,,	,,	,,
15	Mr. T.	?	Strong	,,	Mild	,,

In considering the conclusions to be drawn from the reactions of the patients to the tests, the case of patient No. 15 will be omitted, as although described as a non-sufferer, this patient turned out on subsequent enquiry to have been resident in Bloemfontein only one month. He had previously lived in Johannesburg where, it is true, he had not suffered from hay fever, but the epidemic under investigation does not occur there; and, as he had not resided in Bloemfontein during the epidemic season his susceptibility had not been put to the test. In view of the fact that he reacted strongly to the pepper tree pollen his condition during the next epidemic season, if he is still in Bloemfontein, will be watched with interest; but, for the reasons already given, he is an unsuitable patient for this particular experiment.

All the patients recorded as susceptible have been resident in Bloemfontein several years and suffer severely every season from the disorder. With most of them I have been in regular communication during the last two seasons, and the group includes some of the worst sufferers in Bloemfontein; indeed, the majority might perhaps be more correctly described as highly susceptible. The patients recorded as not susceptible, the controls, had also been resident in Bloemfontein during several epidemic seasons and without having suffered. All the patients, therefore, with the exception of No. 15, were eminently suitable for the purpose of the experiments.

The scarifications were made on the outer side of the upper arm, four on each patient, about one and a half inches apart, and the materials tested were laid on the skin and gently mixed with the exuding serum; in the case of the solutions as much liquid was used as would conveniently stay on the scarified region without running off.

Neat Pollen.

Very great difficulty was experienced in obtaining the pollen in sufficient quantity. The weather at the time was dull and moist, and when a flowering male shoot was shaken the open male flowers fell off, but very little pollen fell out of the anthers. Even when the flowers were dried, crushed, and passed through a fine sieve, examination proved that it was the half empty anthers that were obtained, most of the pollen having stuck to the sieve and other utensils with which it had been brought into contact. Attempts to pick the pollen out of the anthers were also unsuccessful, partly again because of the stickiness of the pollen, but mainly, in this case, on account of the minute size of the anthers. Finally, a method was devised by which the very stickiness of the pollen, the character which had caused most of the difficulty, was used to separate it from the flower. The open fresh flowers were shaken from a male shoot and were then rolled or rubbed between two circular sheets of plate glass of a size such as to be easily held in the open hand. The pollen stuck to the glass and was then easily removed with a razor and transferred to a bottle. The material obtained in this way was found to be almost pure pollen, with

only a slight admixture of small fragments of the flower. It is noteworthy that the pollen popularly regarded as causing these epidemics should be so sticky, as according to all the canons of hay fever this character should effectively prevent it from being dispersed through the air. The comparative purity of the pollen prepared in the manner described was probably because no other part of the flower could adhere to the smooth surface of the glass.

When the neat pollen was applied to the scarified skin it was noticed that the pollen become invisible almost immediately. This is probably to be explained by the dissolution in the blood serum of the oil which occurs on the outside of the pollen grains and bears the pigments which give the pollen its colour.

It will be noticed on reference to the table that all the patients susceptible to the epidemic reacted either strongly or very strongly to the pollen, whereas no non-susceptible persons gave any reaction whatever, either to the pollen itself or to the other materials employed. The non-susceptible patients were therefore satisfactory as controls, and the conclusion is justified that pepper tree pollen can cause hay fever.

Saline Extract.

For the saline extract of pepper tree pollen I am indebted to the South African Institute for Medical Research, Johannesburg, where the method followed in preparing it was that described by Dr. Scheppegrell, in the U.S. Public Health Reports, Vol. 32, No. 29, July 20, 1917. Considerable difficulty was experienced in obtaining and manipulating the pollen owing to its stickiness, and Dr. Harvey Pirie, of the Institute, writing in regard to the extract states that "when preparing the extract . . . . I found it very difficult to get the pollen off, the grains appear to be very sticky," and that though "the extract aimed at being a 1 in 10,000 extract of pollen, it was impossible to get the pollen in any quantity separate from the flowers," and it "may have been much under 1 in 10,000 as regards the pollen." These statements confirm my experience at Bloemfontein with regard to the stickiness of the pollen, and also no doubt partly explain the weak reactions to the extract.

On reference to the table it will be seen that of the nine susceptible patients who, as has been stated, reacted strongly, or very strongly, to the neat pollen, only four reacted to the extract, and in all cases only very mildly, whilst two of these patients reacted, in the one case as strongly, and in the other case more so, with saline only. It should here be explained that the reactions of patient No. 3 to the reagents other than neat pollen are probably unreliable, as the swelling and reddening resulting from the application of the neat pollen spread so as quickly to envelop the centres at which the other three reagents were applied. Incidentally, this experience shows that where more than one centre is being inoculated these should be at some considerable distance apart.

As this was only a preliminary attempt at preparing the extract in which there was no evidence as to the strength required and in which the peculiar difficulties of this particular pollen has not been entirely overcome, it is perhaps not surprising that the extract did not react better. But even apart from this, a consideration of the biochemistry of the pollen grain leaves doubt as to whether the method of preparation (which is a standard one) can always achieve what is aimed at. According to the prevailing opinion hay fever is due to toxic proteids contained in the pollen grain, and these the extract aims at bringing into solution; but, as Mr. Philip Smith (1920) has pointed out, these proteids being colloids, are unable to pass through the cell walls of the pollen grain and would only escape if the pollen grains burst. This being so, it seems essential that the solvent used in preparing the extract should be one in which the pollen concerned burst freely. I have tested the behaviour of pepper tree pollen in this connection and find that whilst the grains burst freely in water their behaviour in salt solution is variable, but, speaking generally, whilst a small proportion burst in normal saline (0.9 per cent. strength), only very few do so in 5 per cent., which is the strength used in Dr. Scheppegrell's method to extract the pollen.

Oil Emulsion.

Observations at Bloemfontein extending over two hay fever seasons had convinced me that pepper tree pollen could cause the disorder. The question, then, naturally arose as to whether part, at least, of the virulence of this epidemic type of hay fever is not due to the irritating oily and resinous substances which are well known to occur in the pepper tree, and some of which may also occur in the oil found on the outside of the pollen. Indeed, severe skin poisoning is well known to be caused by several species of Rhus (a genus belonging to the same family as, and nearly related to the pepper tree), especially by *R. toxicodendron*, the poison ivy, and *R. venenata*, the poison elder. According to Philip Smith (1920), Pfaff (1897) has succeeded in isolating the poisonous principle—a very sticky, non-volatile oil, which in these plants occurs not only on the stem, leaves and fruit, but also on the pollen. Such an oil would not be extracted by soaking the pollen in 5 per cent. saline.

The solution of this oil and its presentation to the patient in a non-irritating medium was attempted by my colleague, Dr. M. Rindl, Professor of Chemistry, who, after soaking the pollen in ether until the yellow oil was dissolved off the grains (a few seconds only), filtered the extract and dropped it slowly into a hot solution of sodium carbonate (0.5 per cent. strength), the object being to form an emulsion of the oil and at the same time drive off the ether, which is a skin irritant. As will be seen from the table, the results were virtually negative. One negative result, however, proves nothing: the question could only be settled by repeated experiments with extracts prepared in several different ways and of various strengths, and preferably from which proteids

had been eliminated. This extract, like that in saline, may have failed entirely to extract the active toxic principle or may have done so in insufficient quantity, yet experience has shown that in the case of many, or perhaps all toxic pollen tried, it has been possible, after a few preliminary trials, to prepare the saline extract in such a strength as to give a reliable reaction.

To the fourth scarified area normal saline, or 0.5 per cent. sodium carbonate was applied. This was done as a sort of control to ensure that any reactions obtained were not due to the scarification itself or to the solvents in which the pollen extracts were dissolved. As, with the exception of patient No. 3, whose response has been accounted for, only one of the fifteen patients gave any reaction at all, and that a very mild one to this control inoculation, the reactions obtained from the pollen itself and the extract may be justly referred to the toxic principles in these materials.

These simple experiments demonstrate conclusively the toxicity of pepper tree pollen; the question of its dispersal and the probable part it plays in causing the epidemics under investigation will be discussed in a subsequent article.

Thanks for aiding in the investigation are due in the first place to the patients who allowed themselves to be inoculated, to Dr. S. M. de Kock, himself a sufferer, who performed the inoculations, and who throughout the investigation has always been most willing to render whatever assistance his time allows; to Dr. W. Watkins-Pitchford, Director of the S.A. Institute for Medical Research; and Dr. J. H. Harvey Pirie, for much friendly and valuable advice; and to Miss Helen Bergstedt, B.Sc., Demonstrator in Botany, for general assistance, especially in preparing the pollen.

References.

1. Pfaff, Fr. (1897). Active Principles of *Rhus toxicodendron* and *Rhus venenata*. Jour. Exper. Med. Vol. ii, p. 181.
2. Potts, G. (1919). The Pepper Tree (*Schinus molle*) in its Relation to Epidemic Hay-Fever. Interim Report. S.A. Journal of Science, Vol XV, p. 525-530.
3. Smith, E. Philip (1920). Plant Dermatitis. Journal of Botany, May, 1920.

NATAL SPECIES OF THE GENUS *CASSIA*.

BY

HELENA FORBES,

Natal Herbarium, Durban.

Read July 12, 1921.

The genus Cassia belongs to the sub-order Caesalpiniae of the order Leguminoseae. It is essentially a tropical and sub-tropical genus, and is best represented in tropical America.

The senna leaves of medicine are the leaves of different species which occur principally in Upper Egypt, Syria, India, Arabia and Senegal. The seeds of a few species are edible. In Natal, *Cassia occidentalis* is used as an ingredient in native antidotes for snake bite, but, apart from this, the Cassias in South Africa are not used medicinally.

The Cassias flower during the late summer or early autumn, and their masses of golden-yellow blooms, make bright conspicuous patches in the bush and along the roadside. *Cassia mimusoides* flowers earlier in the year--October to March usually—and is a small, diffuse plant.

The plants vary from tall woody shrubs to small diffuse herbs. The flowers are perfect, with five slightly perigynous sepals; five yellow, unequal petals; ten stamens, of which seven are fertile, unequal and open by apical pores, and three abortive. The ovary is superior, many seeded and stipulated. The fruit is a linear, terete or compressed, many-seeded legume.

KEY TO SPECIES OF CASSIA.

Leaves densely tomentose (1) *tomentosa.*
Leaves finely tomentose (2) *Delagoensis.*
Leaves glabrous.
  Leaflets large, varying from 4 cm. to 10 cm. long.
    Leaflets 3 to 4 pairs, ovate, acuminate (3) *laevigata.*
    Leaflets 4 to 6 pairs, ovate to lanceolate, reddish tinge on petioles, mid-ribs, etc. (4) *occidentalis.*
  Leaflets small, not exceeding 4 cms.
    Leaflets 12 to 45 pairs, lanceolate (5) *mimosoides.*
    Leaflets 4 to 5 pairs, ovate, brown, margin round edge of leaflets (6) *bicapsularis.*

(1) *Cassia tomentosa*, Lam.

A tall shrub with densely pubescent branches and leaves. Leaflets 4 to 6 pairs, oval-oblong, obtuse, tomentose, 2.5 cm. to 8 cm. long, 1 cm. to 4 cm. broad; petiole grooved, tomentose, with a gland at the base; stipules about 0.5 cm. long, narrow, pubescent, deciduous; peduncles short, 4 to 6 flowered; sepals unequal, five, two outer light green, hairy, three inner larger, yellowish-green, two glabrous, one slightly hairy; petals unequal,

five, yellow; stamens 10, 7 fertile, two long, one medium, four short; 3 staminoids; ovary woolly, legume linear, acute, compressed, villosa-tomentose, 10 cm. to 12 cm. long, many-seeded.

Introduced from tropical America. Not such a handsome shrub as *C. laevigata* or *C. bicapsularis*, as the clusters of flowers are not so large. Flowers during the autumn months.

(2) *Cassia Delagoensis*, Harv.

An erect shrub, thinly pubescent. Leaflets 6 to 5 pairs, petioles short, a slender filiform gland; 0.3 cm. to 0.4 cm. long between each pair of leaflets; leaflets lanceolate, acuminate, under surface paler than upper surface, 2 cm. to 6 cm. long, 0.8 cm. to 2.2 cm. wide, stipules reniform, with one lobe tailed, deciduous; racemes axillary, pedunculate, many flowered and forming a terminal corymbose panicle; sepals two, small, softly hairy; petals five, unequal, veined, orange yellow; stamens 10, three long, incurved, 0.7 cm. to 0.9 cm. long, four 0.4 cm. to 0.5 cm. long, three short and broad staminoids; anthers opening by apical pores; ovary 1.3 cm. to 1.5 cm. long, slightly incurved, soft silky pubescence slender, multi-ovulate.

A native of tropical Africa and Australia.

(3) *Cassia laevigata*, Willd.

An erect glabrous shrub, 4 feet to 6 feet high. Leaflets 3 to 4 pairs, ovate to lanceolate, usually acuminate, 3.5 cm. to 7.5 cm. long, with an oblong or slender gland between each pair; racemes axillary, pedunculate, short and almost corymbose, the upper ones forming a short terminal panicle, sepals unequal, the inner ones 0.6 cm. to 0.8 cm. long; petals broad, very obtuse, varying from 0.7 cm. to 1.9 cm.; perfect anthers 4, almost sessile, one on a short, and two on much longer filaments; legume 5 cm. to 7.5 cm. long, membranous or slightly coriaceous, cylindrical or more or less inflated when ripe, opening at length into two valves; seeds crowded and horizontal, or upper ones less crowded and almost vertical.

A cosmopolitan tropical plant. A very handsome shrub when in full bloom.

(4) *Cassia occidentalis*, Linn.

A nearly glabrous shrub, 3 feet to 4 feet high, with a reddish-brown tinge on stems, petioles and legumes. Leaflets 3 to 4 pairs, ovate-lanceolate, 2.5 cm. to 7.5 cm. long, 1.5 cm. to 2.5 cm. wide, glabrous, petiole with a short obtuse gland at base, gland deep red; stipules deciduous, membranous, lanceolate or ovate-lanceolate; inflorescence few flowered; sepals glabrous, with a reddish tinge, unequal; petals unequal, yellow; stamens, 7 fertile, unequal, 3 staminoids; ovary softly pubescent, not woolly; legume 10 cm. to 15 cm. long, linear, elongate, reddish-brown with thick green margins, glabrescent, plano-compressed.

A cosmopolitan tropical plant. It is usually an annual, but it is stated by Dr. Welwitsch to be also of two to three years duration. The whole plant has a rather disagreeable smell.

(5) *Cassia mimosoides*, Linn.

Erect, slender, branching, 1 foot to 2 feet high, or a suffrucicose herb, glabrescent; leaflets 30 to 50 pairs, with a reddish gland between the lowest pair; leaflets minute, mucronulate, rigid, linear-falcate; 0.2 cm. to 0.3 cm. long; stipules striate, subulate from a semi-cordate base; peduncles axillary, 1 to 3 together, 1 flowered, sepals five, brownish-green, ovate, acute, hairy; petals five, yellow, slightly irregular, obtuse; stamens 10, 7 fertile, unequal, 3 staminoids; anthers opening by apical pores; ovary sessile or stipitate, very hairy, multiovulate; style filiform; stigma simple; legume linear, 3 cm to 4 cm. long, compressed, margins thickened, hairy, 10 to 25 seeds in each legume; seeds brown, about 0.2 cm. long and 0.1 cm. broad.

var. *capensis*. diffuse; leaflets 10 to 35 pairs, with gland at base of petiole.

var. *stricta*. erect, virgate; leaflets 30 to 40 pairs with a large ellipsoid gland at base of petiole.

var. *comosa*. erect, glabrous; leaflets 8 to 30 pairs, with large gland at base of petiole.

A cosmopolitan tropical plant. It is sensitive to rain and darkness, and also to touch. When plucked the leaves close together and do not reopen. The plant appears to flower the whole year round, but best between October and March, when it is a blaze of golden-yellow.

Cassia bicapsularis, Linn.

An erect glabrous shrub attaining a height of over 5 feet. Leaflets 4 to 5 pairs, base of petiole short and swollen, small yellowish gland between lowest pair of leaflets, in groove of common petiole; leaflets obtuse, upper surface dark green, lower surface slightly greyish tinge, light brown margin round each leaflet, 1.5 cm. to 4 cm. long, 0.6 cm. to 1.5 cm. broad; racemes axillary, pedunculate, short and almost corymbose, the upper ones forming a short terminal panicle; sepals unequal, greenish-yellow, glabrous; petals irregular, broad, obtuse, bright yellow; 7 fertile stamens, 3 staminoids, flat and sessile, four perfect anthers slightly sessile, one on a short filament and two on much longer filaments, all opening by apical pores; ovary 2.5 cm. long, glabrous, light green, multiovulate; legume 8 cm. to 10 cm. long, membranous or slightly coriaceous, cylindrical or more or less inflated when ripe, opening at length into two valves.

A native of tropical America. The leaves of this species are sensitive to rain and also to darkness, and fold up in a rather peculiar manner. The lower pairs of leaves fold up along the stem towards the apex, and the top pair—which are the largest—fold over the others.

NOTES ON SOME INTERESTING OR LITTLE-KNOWN SOUTH AFRICAN FUNGI.

BY

Paul A. van der Bijl, M.A., D.Sc., F.L.S.,
Professor of Mycology, University of Stellenbosch.

Read July 15, 1921.

The following notes on certain South African fungi may be of interest:—

1. The genus Campanella, P. Henn.

The genus Campanella belongs to the family *Agaricaceae*, or "mushroom family." It differs from the majority of this family by having the hymenophore composed of anastomosing veins and not of distinct gills or plates. On this character the genus is with others placed in the tribe *Cantharelleae* of the *Agaricaceae*.

I once collected *Campanella Buttneri*, P. Henn, fairly frequently on rotting branches in the bush around Durban. The plants are gelatinous, white to yellowish in colour, and stalked; the cap is reniform and measures 1 mm. to 5 mm. across; the hymenophore is borne on the underside of the cap and is composed of anastomosing veins; the stalk is 0.5 mm. to 1 mm. long and curves close to the insertion of the cap, so that the hymenophore comes to face upwards; the basidia are club shaped and the spores hyaline, 3μ to $4\mu \times 7\mu$ to 8μ in diameter.

This fungus was originally described from Togoland and the Cameroons, and, as far as I am aware, has not previously been collected in the Union. In Engler and Prantl the cap is said to be "hautig," which is surely an error.

2. Some Geasters.

The Geasters or "earth star" fungi are familiar to most people and are usually met with on rich humus soil in bush. Two are now described which have very little resemblance to each other, namely, *Geaster coronatus* and *Geaster saccatus*.

Geaster coronatus (Schaff) Schroter.

The outer peridium is split into four to six subequal, acute, deeply cut segments and arches over the mycelial layer, which forms a more or less imperfect cup at the base; inner peridium is ash coloured, covered with fine granules, subglobose, 10 mm. to 12 mm. diameter, shortly pedicillate; stalk 2 mm. to 3 mm. long, 1 mm. to 2 mm. diameter; mouth protruding acute, seated on a definite circular area different in colour from the rest of the endoperidium; spores in mass dark brown, globose, finely warted, 3μ to 7μ diameter. Capillitium of long unbranched threads, approximately 3.7μ in diameter

The warts on the spores are very fine and most evident under an oil immersion lens. This fungus is common in the bush around Durban, though previous collectors do not record it. It is included in the "fornicate" section of the genus which has as its characteristic the segments of the outer peridium arching over the mycelial layer, which persists more or less as a cup at the base.

The plant originally is buried in the rich leaf mould in which it is commonly found, the cup formed mycelial investment remains in the substratum and the turned back segments of the outer peridium rest on the edges of this cup-shaped mycelial investment.

Geaster saccatus, Fries.

Exoperidium cut into six to ten segments for about half its length, base deeply saccate; endoperidium sessile, globose, 0.7 cm. to 1 cm. in diameter, ashy grey; mouth as in preceding species seated on a definite circular area differing in colour from the rest of the surface; spores,, dark brown in mass, globose, rough with minute projections to practically smooth, 3μ diameter; capillitium of unbranched tubes as in previous species.

This species is common around Pretoria and occurs also in the midlands of Natal. With other species it is placed in the section *Saccatus* owing to the base of the exoperidium remaining as a cup in which is the endoperidium. In the majority of Geasters the exoperidium is turned back away from the endoperidium and the saccate species number only four.

3. The genus Catastoma.

The genus Catastoma belongs to the Lycoperdaceae, or "puffball" family, and is, with other genera, placed in the tribe Bovistae. This tribe embraces those puff-balls which at maturity become loosened from their place of growth and may thus be moved along the ground by the wind. They are for this reason also known as the "tumbler puff-balls." There are about three species of Catastoma in South Africa, and the one described differs from all the others in that the inner peridium opens by a protruding mouth.

Catastoma anomala.

Plants terrestrial, becoming loosened from attachment at maturity, globose; outer peridium breaking away irregularly, more or less persistent at base; endoperidium ash coloured, globose, 1 cm. to 1.5 cm. diameter, opening by a strongly protruding mouth; spores in mass amber brown, globose, 4μ diameter, smooth; capillitium of light coloured, undulating, short unbranched threads with blunt ends, of same diameter as the sports. The capillitium threads as above recorded are characteristic of the genus *Catastoma*. I find that the spores are smaller than those usually recorded for this species (6μ to 7μ). The spores are said to be slightly rough but are smooth in my specimen. The specimen was collected at about 115 feet above sea level. The species occurs in other countries.

4. The genus Lanopila, Fr.

This genus also belongs to the Bovistae or "tumbler puff-balls," and was founded by Fries in 1848 for a fungus collected in South Africa by Wahlberg and named *Lanopila wahlbergii*, Fries. The genus is close to Bovista; in fact, so close that it is doubtful if it is really distinct from it. In Bovista the capillitium is composed of short, separate, much branched threads with slender pointed branches, whereas in *Lanopila* the threads are long and interwined and it is believed that they cannot be separated. This appears to be the only difference between the two genera. Since described by Fries this fungus has been lost sight of, and our collection is the first from South Africa from that date. The genus is monotypic, all other described species being now referred to *Lanopila wahlbergii.*

Lanopila wahlbergii, Fr.

Plants terrestrial becoming loosened from attachment at maturity, without sterile base, subglobose, 5 cm. to 1.5 cm. diameter; endoperidium, papery, potato colour, peeling off and exposing the amber brown gleba composed of capillitium threads and spores; capillitium of thin, branched and interwoven threads, 1.6μ to 3μ diameter, forming a homogeneous elastic mass. Spores globose, dark strongly echinulate, 5μ to 7μ diameter.

The genus Lanopila is evidently close to the monotypic Indian genus Lasiosphaera. The gleba and spores are the same in both.

5. *Hymenochaete tenuissima*, Berk.

Pileus sessile, imbricate, 3 mm. to 4 mm. long by 1 mm to 3 mm. broad, laterally connate, extremely thin and flexible, surface zoned, furrowed, reddish-brown, villous; hymenium snuff brown; setae projecting 20μ to 30μ, 4μ across at base, tapering to the apex; spores (teste Massae) ellipsoid 5.6μ by 3μ.

This fungus appears to be rare in South Africa, and was collected for the first time by W. Haygarth in the Forest of Zululand in 1916. Its extreme thinness and flexibility are remarkable and should assist in recognising it.

6. *Lycoperdon djurense*, P. Henn.

Peridium globose to flattened, 1.5 cm. to 2.5 cm. diameter; cortex closely warted, falling away in places or with age; sterile base of large cells; gleba purple; capillitium hyaline, 5μ to 8μ diameter; spores globose, smooth, 3.8μ diameter.

The specimens were collected by the writer at Schroeders, Natal. The purple gleba is the distinguishing characteristic of this Lycoperdon.

7. *Cladoderris spongiosa*, Fries.

This fungus was first described in 1848 bv Fries in his "Fungi Natalensis." It appears not uncommon in the forests of Zululand. The plant is recognised by the stipitate infundibuliform

to flabelliform pileus, covered on the upper surface with a dense, spongy tomentum. The hymenial folds on the under surface of the pileus are broad and warted.

8. *Pleurotus applicatus*, Batsch.

A small sessile agaric is at times not uncommonly met with in the bush around Durban growing on wood lying on the ground and is referred to *Pleurotus applicatus*, Batsch. It has not previously been recorded from South Africa, and the following brief description is given to aid in its recognition.

Cap sessile, imbricate, shell shaped, 0.4 cm. to 1.2 cm. across, gray to bluish-gray or blackish, glabrous to pruinose or finely hairy; gills gray, radiating, distant, broad in proportion to size of plant. The upper layer of the pileus is gelatinous, and dried plants readily revive if placed in water.

THE FLORA OF ISIPINGO.

BY

HELENA FORBES,

Botanical Assistant, Natal Herbarium, Durban.

Read July 12, 1921.

Isipingo is a well-known seaside resort about one hour's journey from Durban. Isipingo Beach is over a mile distant from the village at the station.

The greater part of the shore, especially on the right-hand side of the Lagoon, is very rocky. Large and small pools abound among the rocks, and their sides are covered with brightly coloured sea-weeds and sea-anemones. The rocks, which are only partially exposed during very low tides, are completely covered with brilliantly coloured sea-weeds. Delicately hued sea-anemones in crevices, pools and on ledges, and large and small sea-urchins, whose shells are covered with long stiff black bristles, are to be found all over the rocks.

The sea-weeds noted have been identified as far as possible by the aid of Miss Frank's collection in the Natal Herbarium. Over seventy different kinds were collected, and less than half have been identified: these latter are given in the following list. *Amphiroa anceps*, *Apjohnia rugulosa*, *Brachyclaria marginata*, *Bryopsis flanagani*, *B. setacea*, *Caulerpa ligulata*, *Chaetomorpha clavata*, *Chondrococcus hornemaii* var. *tripinata*, *Codium adhaereus*, *C. tomentosum*, *Corralopsis aculeata*, *Dasya* sp., *Dictyota liturata*, *Dictyota* sp., *Epymenia stenoloba*, *Galaxaura obtusata*, *Gelidium cartilagineum*, *Gelidium* sp., *Griffithsia corallina*, *Gymnogongrus polycladus*, *Halymedia cuneata*, *Hypnea eckloni*, *Laurencia* sp., *Leathesia* sp., *Martensia elegans*, *Mastophora lamourouxii*, *Mychodea* sp., *Nitophyllum* sp., *Padina commersonii*,

Plocanium corallorhiza, *Polysiphonia* sp., *Polyzonia elegans*, *Sargassum vulgare*, *Sprydia horridula*, *Ulva fasciata*, *Valonia* sp., and *Vanoorstia spectabilis.*

The phanerogamic seaplant, *Zostera marina* (Sea grass), is also found washed up on the beach.

The beach is approached by a road leading alongside the Lagoon. On the Lagoon side *Avicennia officinalis*, *Bruguiera gymnorhiza* and *Hibiscus tiliaceus* form a barrier between land and water. *Triglochin bulbosum* and *T. striatum* grow in the mud; *Panicum laticomum*, *P. laevigata*, *Emex australis*, *Sporobolus indicus*, *Gomphrena globosa*, *Boerhaavia ascendens*, *Amarantus spinosa*, *Chenopodium ambrosoides* and *Dactyloctenium aegyptiacum* grow on the bank and at the roadside. Further along the road on the same side, creeping among the stones and grass, is *Ipomea biloba.*

On the other side of the road the growth is fairly dense, and consists of *Schmidelia erosa*, *Sideroxylon inerne*, *Trema bracteolata*, *Cordia caffra*, *Osteospermum moniliferum*, *Cestrum laevigata* (an escape from cultivation), *Ficus natalensis*, *F. burt-davyi*, while *Senecio tamoides*, *Ipomea ficifolia*, *Cynanchum natalitium*, *C. obtusifolium* and *Rhynchosia spp.* twine themselves among the branches.

Towards the sea-front *Osteospermum moniliferum* becomes the dominant plant, and other plants, such as *Othonna carnosa*, *Passerina rigidula*, *Brachylaena discolor*, *Barleria obtusa*, *Carissa grandiflora*, *Helichrysum teretifolium*, *Mesembryanthemum acinaciforme*, *Anthospermum littoreum* and clumps of *Strelitzia augusta*, become more common.

Where the hillside is exposed to the sea winds, the plants are more or less of a rambling nature or low lying. Some parts are carpeted only with *Cynodon dactylon* and *Dactyloctenium aegyptiacum*, but the growth is principally a dense mass of *Helichrysum teretifolium*, *Gazania uniflora*, *Dimorphotheca fruticosa*, *Carissa grandiflora* (resembling a low rambling shrub), *Helichrysum krausii*, *Asparagus sarmentosus*, *Turreae obtusifolia*, *Cynanchum spp.*, *Mesembryanthemum acinaciforme* and *Ceteospermum moniliferum.* Higher up *Aloe thraskii* stands out prominently.

In some places the hillside is very sandy, especially in two little bays where the waves dash up, their force unbroken by rocks. The sand is loose and is continually falling, as it is not held together by grass, or densely clothed with plants. Those plants which exist are *Passerina rigidula*, which is dominant, *Selenium subfruticosum*, *Othonna carnosa*, *Kalanchoe rotundifolia*, *Lauzea bellidefolia*, *Tephrosia canescens*, *Celastrus procumbens*, *Salacia kraussii*, three species of *Crassula* and *Mesembryanthemum spp.* Creeping along the sands are *Ipomea biloba* and *Canavalia obtusifolia.*

Growing in crevices of the rocks where it appears practically impossible for anything to exist, are *Euphorbia livida*, *Chenolea diffusa*, *Gazania uniflora*, *Aizoon canariense*, *Mesembryanthemum cordifolium*, *Sonchus olearcus* and *S. echlonianus.*

Behind the bathing booths the bank is a dense mass of *Barleria obtusa*, *Hypoestes verticillaris*, *Cissus cirrhosa*, *Droguetia urticoides*, *Asystasia coromandeliana*, *Osteospermum moniliferum*, *Ipomea purpurea*, *Plectranthus* sp., *Mesembryanthemum cordifolium*, *Crassula* spp., while further up it changes and *Mimusops caffra* and other shrubs take the place of flowering herbaceous plants.

The vegetation along the beach to the Umbogintwini Lagoon is very similar. Beyond the Tiger Rocks *Aloe thraskii* is dominant, but otherwise the bush consists of *Mimusops caffra*, *M. obovata*, *Eugenia capensis*, *Celastrus procumbens*, *Carissa grandiflora*, *C. arduinia*, *Salacia kraussii*, *Rhus natalensis*, *Passerina rigidula*, *Gazania uniflora*, *Strelitzia augusta*, *Cynanchum spp.*, *Ficus natalensis*, *Sideroxylon inerne*, *Celastrus buxifolius*, and others which have been mentioned above.

To leave the beach we climb up steep or slanting sandy paths. The beach flora continues for the greater part, but other varieties also begin to appear. Small shrubs of *Ficus polita*, *F. natalensis* and *F. burtt-davyi* are common, and also *Trema bracteolata*, *Tricalysia senderiana*, *Voacanga dregei*, *Sapindus oblongifolius* and *Euclea natalensis*. There are also a great many twining plants which creep over the shrubs and along the ground, namely, *Ipomea spp.*, *Tragia durbanensis*, *Secamone gerrardii*, *Desmonema caffrum*, *Heliophila scandens*, *Coccinea palmata*, *Droguetia urticoides*, *Plectranthus sp.*, *Senecio macroglossus*, and *S. quinquelobus*. Growing among the shrubs are *Chenopodium ambrosoides*, *Celosia trigyne*, *Pupalia atropurpurea*, *Chironia baccifera*, *Samolus prosus*, *Sanseviera quineensis*, *Gloriosa verescens*, *Oldenlandia macrophylla*, *Spermacoce natalensis*, *Solanum dupli-sinatum* and *Phylopsis parviflora*.

Most of the ground along the front of the ridge has been cleared for building purposes, but the inland side of the hill is practically untouched, and the vegetation is, in most parts, very dense. The trees which are met with are *Euclea natalensis*, *Baphia racemosa*, *Sapium reticulatum*, *Albizzia fastigiata*, *Brachylaena discolor*, *Erythrina caffra*, *Fagara capensis*, *Apodytes dimidiata*, *Trimeria alnifolia*, *Chaetacme aristata*, *Royena cordata*, *Royena sp.*, *Melia azedarach*, *Acokanthera spectabilis*, *Sapindus oblongifolius*, *Sclerocarya caffra*, *Turreae floribunda*, *Pteroxylon utile*, *Protorhus longifolia*, *Oncoba spinosa*, *O. kraussiana*, *Eugenia cordata*, *Cassinopsis capense*, *Ilex capensis*, *Zizyphus mucronata*, *Trema bracteolata*, *Antidesma venosum*, *Cordia caffra*, *Eugenia capense*, *Ficus spp.*, *Grewia cana*, *G. occidentalis*, *G. caffra*, *Strychnos gerrardii*, *S. henningsii*, *Croton sylvaticum*, *Homalium sp.*, *Toddalia natalensis*, *Ochna arborea*, *Mimusops caffra* and *M. obovata*.

There are also a great many shrubs, many of which have beautiful masses of bloom. Among these *Bauhinia tomentosa* is dominant, while others are *Uhdea bipinnatifida*, *Tithonia tagetifolia* (introduced plants which are spreading all along the coast), *Clerodendron glabrum*, *Burchellia capensis*, *Gardenia globosa*,

Crotalaria capense, *Tricalysia sonderiana*, *Mitriostigma axillare*, *Randia rudis*, *Kraussia floribunda*, *Dalbergia obovata*, *D. armata*, *Entada natalensis*, *Plectronia ciliata*, *P. obovatum*, *P. ciliata* var. *glabrata*, *Vangueria latifolia*, *V. lasiantha*, *Pavetta natalensis*, *P. obovata*, *Acalypha glabrata*, *Pavetta lanceolata*, *Maerua nervosa*, *Niebuhria triphylla*, *Vangueria infausta*, *Dichrostachys nutans*, *Voacanga dregei*, *Psychotria capensis*, *Euclea lanceolata*, *Celastrus luxifolius*, *C. verrucosus*, *C. procumbens*, *C. nemorosus*, *C. acuminatus*, *Rauwolfia natalensis*, *Hippobromus alata*, *Ricinus communis*, *Cassia occidentalis*, *Plectronia ventosa*, *Solanum giganteum* and *Turreae obtusifolia*.

The creepers and rambling shrubs are many, and as most of them have fine masses of flowers, they enhance the beauty of the bush considerably. There are four very fine ones which flower during May and June, *Senecio tamoides*, *S. deltoides*, *S. angulatus*, and *Veronia angulifolia*. Other two Senecio creepers are *S. macroglossus* and *S. quinquelobus*. Besides these there are *Smilax kraussiana*, *Abrus precatorius*, *Rhiocissus rhomboidea*, *Dioscorea malifolia*, *D. rupicola*, *Scutia commersonii*, *Rhiocissus capensis*, *R. digitata*, *Rhus natalensis*, *Rumex saggitatus*, *Pyrenacantha scandens*, *Sphaerosicyos sphaericus*, *Ophiocaulon gummifera*, *Ipomea purpurea*, *I. ficifolia*, *Coccinea palmata*, *Capparis zepheria*, *Mormordica involucrata*, *Cephalandra palmata*, *Cissampelos pariera*, *C. torulosa*. *Glycine javanica*, *Rhynchosia sp.*, *Vigna luteola*, *Ipomea palmata*, *Zehneria sp.*, *Rubia cordifolia*, *Tragia durbanensis*, *Teramnus labiales*, *Vigna vexillata*, *Dalechampia capense*, *Mikania natalensis*, *Asparagus africanus* var. *wrightii*, *A. plumosus*, *A. falcatus* and *Asparagus sp.*

There is, naturally, a dense undergrowth in parts, and here a very great variety of plants is to be found. *Pavonia dregei* and *Barleria obtusa* are two very common and pretty shrubs. *Barleria obtusa* often resembles a climber or a wild rambling shrub, and its sprays of blue flowers look extremely handsome and effective against the green foliage of the trees or neighbouring shrubs. Two other handsome flowering undershrubs are *Hypoestes antennifera*, whose purple blooms are very pretty and conspicuous, and *Leonotis leonurus*, a shrubby plant with bright orange coloured flowers, blooming during the early winter months. Other undershrubs and herbaceous plants are: *Priva leptostachya*, *Plectranthus laxifolius*, *Sida rhombifolia*, *S. rhombifolia* var. *S. cordifolia*, *Sutera floribunda*, *Triumfetta rhomboidea*, *T. effusa*, *Wahlenbergia undulata*, *Ageratum conyzoides*, *Asystasia coromandeliana*, *Achyropsis leptostachya*, *Berkheya maritima*, *B. debilis*, *B. seminivea*, *Lantana salviaefolia*, *Abutilon indicum*, *Justicia sp.*, *Gnaphalium undulatum*, *G. purpureum*, *Gynandropsis pentaphylla*, *Chlorophytum modestum*, *Anthericum pulchellum*, *Thunbergia dregeana*, *T. atriplicifolia*, *Crotolaria grantiana*, *Kalanchoe retundifolia*, *Cassia mimosoides*, *Dracaena hookeriana*, *Dicliptera heterostegia*, *Felicia erigeroides*, *Aster asper*, *Nicandra physaloides*, *Withania somnifera*, *Physalis peruviana*, *Helichrysum auriculatum*, *H. decorum*, *H. cooperi*, *Fleurya capensis*, *Fleurya sp.*, *Datura stramonium*, *Drimiopsis maculata*, *Chenopodium album*, *C. ambrosoides*, *Cyano-*

tis nodiflora, *Crocosmia aurea*, *Lochnera rosea* (both pink and white species), *Indigofera spp.*, *Hibiscus natalensis*, *H. surratensis*, *H. gossypinus*, *H. physaloides*, *Haemanthus natalensis*, *Hypoestes verticillaris*, *H. triflora*, *Stachys aethiopica*, *Hypoestes phaylopsoides*, *Helichrysum pannosum*, *Indigofera endecaphyalla*, *Isoglossa cooperi*, *Oldenlandia natalensis*, *Phaylopsis parviflora*, *Achyranthes robusta*, *Anthericum hirsutum*, *Amarantus spinosus*, *Pupalia atropurpurea*, *Hermbstoedtia caffra*, *Cyathula cylindrica*, *Psilotrichum africanum* and *Pentanisia variabilis*.

Besides the above mentioned there are several small plants which are found in cleared spaces among the grass or in the shade of trees. These are *Hydrocotyle asiatica*, *Lobelia natalensis*, *Diascia cordata*, *Aerva lanata*, *Aneilema aquinoctiale*, *Coleotrype natalensis*, *Commelina africana*, *Alternanthera achyrantha*, *Oldenlandia decumbens* and *Desmodium hirtum*.

Noxious weeds are to be found everywhere, growing at the roadside, in the bush and near the swamps. Under this list may be included *Bidens pilosa*, *Siegesbeckia orientalis*, *Xanthium strumarium*, *Acanthospermum hispidum*, *Emex australis*, *Triumfetta spp.*, *Gomphrena globosa*, *Richardsonia pilosa* and *Alternanthera achyrantha*.

The wild banana, *Strelitzia augusta*, is very common all over the hill, and there are also several fine specimens of *Euphorbia ingens*. *Cestrum laevigata*, although an introduced plant, is quite naturalized here, and it is continually occurring in the bush.

The Lagoon separates the golf course and the fine sandy beach in front from the residential part of Isipingo Beach. To reach the golf course it is necessary to cross the island which is connected to both mainlands by bridges. An account of the island flora is now given.

The island is practically encompassed by mangrove trees, *Bruguiera gymnorhiza*, *Avicennia officinalis* and a few trees of *Rhizophora mucronata*, intermingled with *Hibiscus tiliaceus* and clumps of *Phragmites communis*. On one side of the island *Sporobolus pungens* grows in dense masses in front of the mangroves. *Triglochin striatum*, *T. bulbosum*, *Salicornia natalensis*, *Juncus oxycarpa*, *J. comatophylla* and *Chenolea diffusa* grow in the mud and are partially submerged at high tide. On the sandy shore where the mangroves are not, as yet, very dense, *Canavalia obtusifolia* and *Ipomea biloba* creep along.

Further back around the margin of a pool grows *Juncus oxycarpa*, and in the swampy ground near by, intermingled with *J. oxycarpa* and *J. lomatophylla*, are *Nidorella anomala*, *N. auriculata*, *Ageratum conyzoides*, *Sesbania aegyptica*, *Ethulia conyzoides*, while further back are *Senecio ruderalis*, *Erigeron canadense*, *Digitaria horizontalis*, *D. eriantha*, *Crotalaria distans*, *C. grantiana*, *Cassia mimosoides* and *Dactyloctenium aegyptiacum*. Near the pool stands a large tree of *Acacia clavigera*, and a little further back are several trees of *Hibiscus tiliaceus*.

Following a path about ten feet from the water's edge we find *Lobelia natalensis* and another species of *Lobelia* growing luxuriantly among the two species of *Juncus* mentioned above, *Pycreus*

polystachya and *Sporobolus pungens*. Mangrove trees and *Hibiscus tiliaceus* form a dense hedge between land and water.

The path leads to a part of the island where the vegetation is very dense. The plants found are similar to those found on the mainland, and are *Schimdelia erosa*, *Melia azedarach*, *Sideroxylon inerne* and the rambling shrub *Scutia commersonii* festooned with *Cynanchum spp.* and *Capparis zeyheria*, while in the undergrowth are the prickly *Rubus rigidus*, *Asparagus falcatus*, *Asparagus sarmentosus*, *Abrus precatorius* and the stinging *Tragia durbanensis*. In more open but sheltered spots *Hypoestes antennifera*, *Phaylopsis parviflora*, *Asystasia coromandeliana*, *Endostemon obtusifolius*, *Crassula sarmentosa*, *Coleotrype natalensis*, *Commelina africana*, *Dicliptera heterostegia* and *Stachys aethiopica* all grow profusely. *Iboza riparia*, *Cannabis sativa*, *Dalechampia capensis*, *Sapindus oblongifolius*, *Acacia spp.*, *Albizzia fastigiata*, *Grewia caffra*, *Dalbergia obovata*, *D. armata*, and several clumps of *Strelitzia augusta* are also growing there. The undergrowth consists of various grasses, *Setaria aurea*, *Panicum laticomum*, *P. laevigata*, *Digitaria eriantha*, *D. horizontalis*, *Sporobolus indicus*, *Tricholaena rosea*, *Anthistiria imberbis*, and a few clumps of *Andropogon nardus*, and also of *Bidens pilosa*, *Senecio ruderalis*, *Sida rhombifolia*, *Nidorella anomala*, *Senecio pterophorus*, *Ceratotheca triloba*, *Cassia mimosoides*, *Siegesbeckia orientalis*, *Hibiscus surratensis*, *H. natalensis*, *H. cannabinus*, *Sonchus olearcus*, *S. ecklonianus*, *Asparagus sp.*, *Triumfetta rhomboidea*, *T. effusa*, and one fern, *Pelleae hastata*.

In one part of the island the soil is almost destitute of all plant life, but almost in the middle of this unfertile place there is a patch of *Aizoon canariense* sheltered by *Nidorella anomala* and *Senecio serratuloides*. Just at the edge of this bare place are several plants of *Mesembryanthemum acinaciforme*.

Leaving the island by the bridge the golf course is reached, and from thence the path to the beach lies through the beach bush. The beach itself is quite a contrast to the beach on the other side of the Lagoon, as there are no rocks at all until the Reunion rocks are reached.

Growing in the sand in front of the bush are *Scaevolia lobelia*, *Hydrophylax carnosa*, *Launea bellidifolia*, *Gazania uniflora*, *Dimorphotheca fruticosa*, *Solanum geniculatum*, *Canavalia obtusifloia* and *Ipomea biloba*.

The bush behind is typical of the vegetation found all along the coast. *Passerina rigidula* is very common, while other plants which are also plentiful are *Putterlichia verrucosa*, *Celastrus buxifolius*, *C. verrucosus*, *C. procumbens*, *Rhus natalensis*, *Carissa arduinia*, *Mimusops obovata*, *Mimusops caffra*, *Carissa grandiflora*, *Fagara capense*, *Euclea natalensis*, *Salacia kraussii*, *Aloe thraskii*, *Scolopia zeyheria*, *Scutia commersonii*, *Rhiocissus rhomboidea*, *Rhiocissus digitata*, *Rhus villosa*, *Rhus natalensis*, *Eugenia capensis*, *Elaeodendron laurifolium* and *Strelitzia augusta*. In the undergrowth *Moreae iridiodes*, *Haemanthus albomaculatus*, *Chlorophytum modestum*, *Polypodium phymatodes*, *Chironia baccifera* and *Medicago denticulata* are to be found.

The golf course has been planted chiefly with *Cynodon dactylon* and very few other plants occur, *Hydrocotyle asiatica* and *Alternanthera achyrantha* being practically the only ones. Two or three plants of *Bulbine asphodeloides* occur near the edge of the course. On one side of the golf course there is a dense bush consisting mainly of the trees just mentioned, and as it extends inland, *Sclerocarya caffra*, *Sideroxylon inerne*, *Euclea lanceolata*, *Ficus spp.*, *Celastrus acuminatus*, *C. nemorosus*, *Brachylaena discolor* and others, previously mentioned, occur.

On the other side there is a narrow belt of trees and shrubs and then a stretch of sand and sand-dunes. This belt of shrubs and plants consists of *Tricalysia sonderiana*, *Peddiae africana*, *Pavetta obovata*, *Cordia caffra*, *Schmidelia erosa*, *Ficus burttdavyii*, *Sapium reticulatum*. *Sideroxylon inerne*, *Scutia commersonii*, *Ficus natalensis*, *Voacanga dregei*, *Trema bracteolata*, *Celastrus buxifolius*. Creeping over the shrubs and along the ground are *Dioscorea malifolia*, *Abrus precatorius*, *Smilax kraussiana*, *Cissus hypoleuca*, *C. cirrhosa* and *Rhiocissus rhomboidea*. Among the shrubs grow *Dracaena hookeriana*, *Sanseviera quineensis*, *Gloriosa verescens*, *Haemanthus natalensis*, *Kalanchoe rotundifolia*, *Asparagus spp.*, *Withania somnifera*, *Hypoestes antennifera* and many others which have previously been mentioned.

In moist places on the sands, and near the river, *Phragmites communis*, *Juncus oxycarpa*, *Scirpus littoralis*, *Kyllingia melanosperma*, *Bulbostylis humilis*, *Ranunculus pinnatus* and *Lepidum capense* were found.

Ricinus communis, *Carissa grandiflora*, *Hibiscus tiliaceus* and *Psidum spp.* (the edible guava) are the principal shrubs on the sand dunes. *Ipomea spp.* and *Cynanchum spp.* have twined themselves about the branches of these shrubs.

Other creeping plants collected were *Lippia nodiflora*, an introduced *Acanthospermum sp.* (not *hispidum*) of which only one patch occurred, *Stenotraphrum glabrum* and *Dactyloctenium aegyptiacum*. Growing on the sand dunes were also *Equisetum ramossimum*, *Salicornia natalensis*, *Chenolea diffusa*, *Cryptostemma nivium*, *Canavalia obtusifolia* and *Ipomea biloba*.

Quite close to, or on the river banks, were growing *Ethulia conyzoides*, *Senecio serratuloides*, *Richardsonia pilosa*, *Laggera alata*, *Eclipta erecta*, *Gnaphalium undulatum*, *Parthenium hysterophorus*, *Jussieae suffruticosum*, *J. repens* (growing submerged in the water), *Cyperus albostriatus*, *Pulicaria capensis*, *Siegesbeckia orientalis*, *Bidens pilosa*, *Polygonum serrulatum*, *Hypochoeris glabrata*, *Nidorella auriculata*, *Ambrosia artemesiafolia*, *Apium graveolens*, *Senecio speciosus*, *S. paniculatis* and *Xanthium strumarium*.

This type of vegetation continues until the sand-dunes are gradually replaced by inland bush. The ground stretching beyond this has been cleared of all bush and is now used for sugar cane plantations. The bush consists of the plants mentioned just before the sand-dune formation, the two main plants being *Schmidelia erosa* and *Carissa grandiflora*. *Polypodium phymatodes*, *Kalanchoe rotundifolia* and *Tricalysia sonderiana* are also

very common. The grasses found are *Tricholaena rosea*, *T. setifolia*, *Imperata arundinaceae*, *Anthistiria imberbis*, *Sporobolus rehmanni*, *Aristida junciformis*, *Cynodon dactylon*, *Dactyloctenium aegyptiacum* and a few clumps of *Andropogon nardus*.

Xanthium strumarium is fast spreading over the sands; in fact, already in some parts it is impossible to walk along without gathering innumerable burrs.

Before describing the Flats, a short account of the river flora will be given. The Umlaas River, which runs into the Isipingo Lagoon, is almost unnavigable unless at high tide. The plants occurring on its banks have just been described. The water from this river divides and one portion flows into the Lagoon while the other takes a bend and runs down on the left-hand side of the island and almost parallel to its former course. It turns again and flows through a channel on the upper side of the island, and so into a fine stretch of water. The bay is surrounded by mangroves, of which *Bruguiera gymnorhiza* is dominant. On the channel side of the island there are about a dozen or so trees of *Rhizophora mucronata*.

The Isipingo River joins the Umlaas River at the channel, and it is navigable for about three miles. Going up the river towards its source there is, on the left-hand side, a dense growth of mangroves, intercepted at intervals by *Hibiscus tiliaceus*, while creeping over the trees are *Scutia commersonii* and *Rhiocissus rhomboidea*. Here and there in front of the mangroves are small banks of *Sporobolus pungens*.

On the right-hand side, immediately opposite the channel, there is a stretch of *Phragmites communis* with several clumps of *Scirpus littoralis*. Below and above are mangroves, but for a short distance they are not nearly so dense as on the opposite side and at intervals *Phragmites communis*, *Scirpus littoralis*, *Dichrostachys nutans* and *Acacia clavigera* occur.

The mangroves are very dense on either side in most places, though they are more continuous on the left-hand side. The other side is more often an intermingled belt of *Phragmites communis*, *Scirpus littoralis*, *Dichrostachys nutans*, *Dalbergia armata*, *D. obovata*, *Acacia clavigera*, *Scutia commersonii*, *Hibiscus tiliaceus*, *Rhus natalensis* and *Phoenix reclinata*. In many places the sugar cane grows right down to the water's edge.

Floating on the surface of the water is *Pistia stratiotes*. In sheltered corners it forms green patches on the surface of the water.

Loranthus dregei is very common on its host *Hibiscus tiliaceus*, and it also grows freely on *Melia azedarach*.

There are very few small plants growing close to the water's edge, but of these *Nidorella anomala* and *Aizoon canariense* are the commonest. Creeping over the trees are *Ipomea purpurea*, *Ipomea palmata* and *Ipomea sp.* The species of *Ipomea* also twine themselves round the stems of *Phragmites communis*.

The ground on either side of the river is, for the most part, utilised for the cultivation of sugar cane.

The Flats, which stretch from the foot of the Isipingo Beach Bluff to the railway station, are used as grazing fields for cattle and consequently the vegetation is stunted in growth.

Between the Beach Hill and the river, marshes occur every here and there, where *Juncus* spp. is dominant, the trees being *Avicennia officinalis*, *Bruguiera gymnorhiza* and *Hibiscus tiliaceus*. All over the Flats the edible guava (*Psidum* sp.) is very common. *Acacia spp.* are also common, and growing in the shade among the species of *Juncus* are *Lobelia natalensis* and *Rhamphicarpa tubulosa*. Parts of the Flats near the river and above the Lagoon are covered with a dense mangrove association and *Scirpus-Juncus* formation.

The plants found on the Flats may be divided into two classes, those found near pools, and those found in the drier parts. Those found near the pools are *Lobelia spp.*, *Physalis minima*, *Aeschynomene uniflora*, *Alternanthera sessilis*, *Polygonum serrulatum*, *Typha natalensis*, *Pharnaceum dislichum*, *Jussieae suffruticosum*, *Oldenlandia macrophylla*, *Hydrocotyle bonariense*, *Spilanthes africana*, *Ranunculus pinnatus*, *Solanum nigrum*, *Sesbania aegyptica*, *Aerva lanata*, *Ambrosia artemesiaefolia*, *Anesorhiza caffra*, *Corchorus trilocularis*, *Floscopa glomerata* and *Eriospermum natalense*.

The plants collected in the drier parts were *Ceratotheca triloba*, *Chenopodium ambrosoides*, *C. album*, *Crotalaria lanceolata*, *C. distans*, *Erigeron canadense*, *Senecio serratuloides*, *Eriosema sp.*, *Cephalaria ustulata*, *Eriosema parviflorum*, *Endostemon obtusifoliums*, *Eclipta erecta*, *Indigofera eriocarpa*, *I. micrantha*, *I polycarpa*, *I. endecaphylla*, *Indigofera spp.*, *Hypochoeris glabrata*, *Galactia tenuiflora*, *Galopina oxyspermum*, *Gelonium africanum*, *Nemesia cynanchifolia*, *Polygala cappillaris*, *P. rarifolia*, *Pulicaria capensis*, *Phyllanthus tenellus*, *P. meyerianus*, *Senecio pterophorus*, *Sutera corymbosa*, *Aloe saponaria*, *Cassia mimosoides*, *C. occidentalis*, *Desmodium incanum*, *Dianthus prostrata*, *Senecio paniculatus*, *S. speciosus*, *Solanum incanum*, *Tephrosia macropoda*, *T. elongata*, *Hypoxis filiformis* and *Hypoxis woodii*.

There are few trees or shrubs other than the mangroves, *Psidium sp.*, *Acacia spp.* and *Hibiscus tiliaceus*, but scattered shrubs of *Brachylaena discolor*, *Ficus cordata*, *Melia azedarach*, *Eugenia cordata*, *Rhus laevigata*, *Dichrostachys nutans*, *Plectronia obovatum*, *P. spinosa* and *Randia rudis* occur. Along the road side rows of *Eucalyptus sp.*, the common blue gum, have been planted, and now in many places young trees are springing up.

There are four formations on the Flats. The first consists of an Andropogon association with *Andropogon hardus* as the dominant plant, next a large patch with *Rubus rigidus* predominating. Then follows the largest portion with *Senecio serratuloides* growing very densely. Among these formations the following plants were collected: *Asclepias physocarpa*, *Scilla rigidifolia*, *Dolichos axilaris*, *Cephalaria ustulata*, *Agrylobium adscendens*, *A. marginatum*, *Tephrosia spp.*, and others which are mentioned above.

The fourth part is a swamp with *Scirpus littoralis* dominant, the plants reaching to a height of from eight to nine feet. *Typha natalensis* is also common, and other plants found are *Jussieae repens*, *Ranunculus pinnatus*, *Kniphofia rooperi* and *Jussieae suffruticosa*.

Following a path that leads alongside a sugar plantation there is, on one side, the swamp formation with *Phragmites communis* dominant. The stems of the cane and reeds are entwined with *Ipomea purpurea*, *I. palmata*, *Cardiospermum halicacabum*, *Ipomea ficifolia*, *Cissus fragilis* and *C. flaviflora*. *Oxalis semiloba* grows in dense masses on the moist banks sheltered by the cane, while other plants growing along the sides of the path are *Dichondra repens*, *Fumaria officinalis*, *Hydrocotyle asiatica*, *Polygonum serrulatum*, *P. lapathifolium*, *Oxalis corniculata*, *Fleurya capensis*, *Plantago major*, *Emex australis*, *Achyropsis leptostachya*, *Achyranthes robusta*, *Polygala hottentotta*, *Vigna luteola*, *Sida rhombifolia*, *Stachys aethiopica*, *Ethulia conyzoides*, *Hyptis pectinata*, *Endostemon obtusifolius*, *Indigofera endecaphylla*, *Tephrosia aemula*, *Ambrosia artemesiaefolia*, *Spilanthus africana*, *Trifolium africanum*, *Ornithogalum virens*, one large clump of *Lotus discolor*, and many of the noxious weeds previously mentioned. Several *Hibiscus spp.*, *H. cannabinus*, *H. surratensis* and *Hibiscus sp.* were found, and also some fine specimens of *Polygala virgata* and *Vigna heliopus*.

A portion of a field that was being prepared for cultivation was almost covered with *Fumaria officinalis*, *Hibiscus natalensis*, *Bidens pilosa* and *Hydrocotyle bonariense*, while in a ditch separating the fields *Plantago major*, *Polygonum lapathifolium*, *P. serrulatum*, *Ranunculus cooperi*, *Polygonum tomentosum*, *Rananculus pinnatus*, *Richardia africana*, *Eriospermum natalense* and *Jussieae suffruticosa* were found, and on the banks *Fleurya capensis*, *Fleurya sp.*, *Asclepias physocarpa*, *Celosia trigyne*, *Eclipta erecta*, *Oxalis semiloba*, *O. corniculata*, *Nidorella auriculata*, *Physalis peruviana*, *Lobelia natalensis*, *Lobelia sp.*, and the common noxious weeds were growing. The banks are shaded by blue gum trees and *Melia azedarach*.

Near the station *Mirabilis jalapa* and *Canna sp.* grow freely, and in swampy parts along the line there are *Kniphofia rooperi*, *Richardia africana*, *Nympheae stellata*, *Ranunculus spp.*, *Pycnostachys reticulata*, *Jussieae suffruticosa*, *Dissotis incana*, *Polygala virgata* and *Nephrodium unitum* growing abundantly.

Other plants which are common towards the inland side are *Leonotis leonurus*, *Erythrina caffra*, *Melia azedarach*, *Eugenia cordata*, *Antidesma venosum*, *Phoenix reclinata* (near streams), *Homalium sp.*, *Clerodendron glabrum*, *Hypoestes antennifera*, *Ficus natalensis*, *Aloe saponaria*, *Andropogon nardus*, *Vernonia angulifolia*, *Senecio deltoides*, *S. tamoides*, *Uhdea bipinnatifida*, *Lantana camara*, *Tithonia tagetifolia*, *Helichrysum spp.* and many others.

Grasses, which form such an important portion of the flora of any district, cannot really be classified as being found in any

one particular district. The same species occur again and again in different parts, both near the beach and towards the interior. *Sporobolus pungens* usually occurs near the mouths of rivers, but the others are more widely distributed. The grasses collected are as follows: *Tricholaena rosea*, *T. setifolia*, *Sporobolus indicus*, *Eleusine indica*, *Anthistiria imberbis*, *Aristida junciformis*, *Andropogon hirtus*, *A. halpense*, *A. filipendulis*, *A. ceresiaeformis*, *A. appendiculatus*, *Digitaria sanguinalis*, *Andropogon nardus*, *Imperata arundinaceae*, *Panicum laticomum*, *P. leavifolium*, *Digitaria horizontalis*, *D. eriantha*, *Urelytrum squarrosum*, *Digitaria ternata*, *Setaria aurea*, *S. sulcata*, *S. verticillata*, *Pennisetum natalense*, *Hiburus alopecuroides*, *Chloris gayana*, *C. pycnothrix*, *Cynodon dactylon*, *Eragrostis chloromelas*, *Diplachne fusca*, *Sporobolus rehmanni*, *S. centrifugens*, *Eragrostis brizoides*, *Oplismenus africanus*, *Paspalum distichum*, *Digitaria diversinervis*, *Stenotraphrum glabrum*, *Dactylectenium aegyptiacum*, *Agrostis verticillata*, *Panicum maximum* and *P. interruptum*.

In moist places and near pools many genera and species belonging to the orders *Cyperaceae* and *Juncaceae* are found, and following have been collected: *Bulbostylis humilis*, *Cyperus albostriatus*, *C. texilis*, *C. isocladus*, *C. compressus*, *C. distans*, *C. natalensis*, *Kyllinga melanosperma*, *K. alba*, *Xyris natalensis*, *Ficinia lacinata*, *Fuirena glabra*, *Scleria meyeriana*, *Pycreus flavescens*, *P. ferrugineus*, *P. polystachya*, *Fimbristylis complanatus*, *Scirpus macer*, *S. prolifer*, *B. zeyheria*, *Maricus sieberianus*, *Bulbostylis kirkii*, *Juncus oxycarpa*, *J. lomatophylla* and *Juncus sp.*

Only one orchid was collected, *Eulophia speciosa*, which was growing quite plentifully on the top of the sandy hill at the beach.

As this survey was done during the months of March, April and May, it is quite possible that many plants occurring in this district have been omitted, especially those which appear only for a short time when flowering. All the plants mentioned were observed by me personally, and every endeavour was made to make the list as complete as possible.

Most of the hills and valleys surrounding Isipingo are planted with sugar cane, so that the natural flora has been almost completely destroyed. Noxious weeds are found everywhere, especially near cultivated soil.

There is very little good soil at the beach as it is of a very sandy nature. The soil on the inland side of the Bluff is better than that of the top or seaward side in this respect, as it is not exposed so much to the salt winds.

Later on, if possible, a list will be added of those plants which have been omitted.

A PRELIMINARY ACCOUNT OF AN INTERSPECIFIC HYBRID AND BACKCROSSES OF *DIGITALIS*.

BY

ERNEST WARREN, D.Sc.,

Director of the Natal Museum, Pietermaritzburg.

With Plates IV, V.

Read July 12, 1921.

For a number of years I have made a study of the inheritance of certain characters in the ordinary garden foxglove (*Digitalis gloxiniæflora*), and some of the results have been published in "Biometrika"[1] and in the "Journal of Science."[2]

I have also made certain observations on the hybrid between *Digitalis gloxiniæflora* and *Digitalis lutea* and on the backcrosses of the hybrid with the parent species; and it is proposed to give a brief summary of the investigation.

It is presumed that *D. gloxiniæflora* is simply a cultivated variety of *D. purpurea*. In any case it is quite fertile and breeds perfectly true on self-fertilisation, and from a genetic standpoint it acts as a pure species.

1. GLOXINIÆFLORA (♀) × LUTEA (♂).

Twenty-five plants of *gloxiniæflora* with varying characters as to shape of flower, colour, etc., were pollinated from six plants of *lutea*. Five flowers in each plant were fertilised. Out of these 125 ovaries, 45 shrivelled very early without result; the remaining 80 grew to a varying size and ripened slowly. Of the ripe ovaries 12 were small and contained nothing, the rest (68) bore some seed. The seeds were very markedly dimorphic, a few were large and broad, while the great majority were very small and relatively narrow (Pl. IV, fig. 1). On the average each of these capsules bore only 4 large seeds and some 2-300 minute seeds. Even the large seeds differed conspicuously from the seeds obtained by the self-fertilisation of the *gloxiniæflora* parent.

The hybrid large seeds were of about the same breadth as that of the ordinary seeds of the female parent but they were very constantly shorter, and consequently appeared squat or squarish. This was not due to the seed accommodating itself to an embryo intermediate in shape between that of *gloxiniæflora* and *lutea*, since although the seed of *lutea* is larger than that of *gloxiniæflora*, yet the average ratio of length and breadth is practically the same

1 Warren, E. "Breeding Experiments with Foxgloves," Biometrika, Vol. XI, 1917.

2 Warren, E. "The Pure Line Hypothesis etc.," S.A. Journal of Science, Vol. XV, 1918-9.

in the two species; the ratio $\left(\frac{\text{Breadth}}{\text{Length}} \times 1000\right)$ being 684 in *gloxiniæflora*, 685 in *lutea*, and 786 in hybrid large seeds and 510 in hybrid small seeds. Both the large and small seeds were commonly capable of germination; but in the case of the small, narrow seeds the cotyledons had the greatest difficulty in freeing themselves from the testa. All the hybrid plants which were subsequently raised were almost certainly derived from the large seeds.

In the development of a normal foxglove seed the nucellus forms a very regular tapetal layer of columnar cells around the embryo-sac (Plate V, fig. 1). As the sac grows, this layer, with the disappearance of the remainder of the nucellus, becomes pushed against the testa, and in the ripe seed the cell-contents disappear entirely, and the cell-walls cease to exhibit cellulose reactions, as shown by being insoluble in strong acids, staining intensely with Sudan III, and by a number of other tests. In ripe, normal seeds the tapetal layer is one cell thick, and this is also generally the case in the large, hybrid seeds (fig. 6); but in the small seeds the layer may be 4 or 5 or more cells thick (fig. 5, *t. l. e. c.*), the condition arising by the more or less regular tangential division of the original layer of cells enveloping the embryo-sac. The hypertrophy of this layer is probably to be regarded as a teratological condition arising through the weak development of the embryo and endosperm. In sections through hybrid seeds, which were found to be incapable of germination, it was seen that sometimes both embryo and endosperm were greatly reduced (figs. 3, 4), or completely absent, and nearly the whole bulk of the original nucellus area was occupied by a thick mass of empty, small, thin-walled cells arranged in radial rows and derived from the excessive tangential division of the single layer of tapetal cells.

2. Lutea (♀) × gloxiniæflora (♂).

The reciprocal cross was tried, with *lutea* as the seed-plant. Ten flowers in each of four *lutea* plants were fertilised with the pollen of *gloxiniæflora*, 25 plants being used. Out of the 40 ovaries some 29 showed signs of development and were harvested. On examination it was found that 18 contained nothing but dried ovules, 5 contained only shrivelled seed, and 6 bore one or more seeds of normal appearance and many shrivelled seeds. The average number of such normal seeds in the 6 capsules was only two. Of these 12 seeds only one germinated with any vigour, and the very young seedling subsequently ceased to grow and died. It is thus quite clear that with *lutea* as the seed-plant the cross is much less easily effected than when *gloxiniæflora* is the seed-plant. The hybrid seeds did not exhibit a similar dimorphic condition as seen when *gloxiniæflora* was the seed-plant; they were either more or less normal in appearance, or were shrivelled and totally incapable of germination.

3. Nature of the Hybrid Plants.

The contents of 14 capsules (*gloxiniæflora* (♀) × *lutea* (♂) were sown in as many separate pans, and 35 hybrid plants were raised. The mortality among the seedlings derived from the large seeds (about 70 in number) did not seem to exceed the normal mortality which occurs in raising foxgloves from seed, but the numerous seedlings which sprang from the minute seeds (many hundreds) were very weak, and I doubt whether any survived.

In general appearance the hybrid plants were not intermediate between the two species; they were much closer to *gloxiniæflora* than to *lutea*.

Leaves.—The ratio of the breadth to the length $\left(\frac{\text{Breadth}}{\text{Length}} \times 1000\right)$ was determined by measuring 15 leaves in each plant. In 15 female parents (*glox.*) the mean ratio $=272$, in 3 male parents (*lutea*) $=168$, and in 27 hybrid offspring $=257$; thus in the relative width of the leaf the hybrid was much nearer to *gloxiniæflora* than to *lutea* (Pl. IV, fig. 2).

The hybrid plants exhibited a greater vigour than that of the parent species. The leaves tended to be smoother and much more shiny than in *gloxiniæflora*, and the margin was much more obviously indentated than in either species. The leaves were often considerably thinner dorso-ventrally than in either *gloxiniæflora* or in *lutea*, and in plucked leaves the rate of the transpiration of water-vapour was much greater than in *gloxiniæflora*. The rate was much nearer the normal *lutea* rate than the *gloxiniæflora* rate.

Flowers.—In general aspect the flowers of the hybrids were closer to those of *gloxiniæflora* than to those of *lutea*. In each plant the four lowest flowers were measured, and the mean was taken as representative of that plant. The following characters were determined: intensity of purple colouration, percentage spotting of lower lip, length of flower, breadth, and the ratio of these two dimensions. The means are given in the following table:—

Generation.	No. of Plants.	Means.				
		Colour Intensity.	Spotting. °/ₒ	Length.	Breadth.	$\frac{\text{Breadth}}{\text{Length}} \times 1000$
D. gloxiniæflora	16	77	20	51·0 mm.	28·4 mm	555
Hybrid ...	31	34	5	46·5	27·7	596
D. lutea ...	17	0	0	35·7	23·9	672

With reference to colour, in the case of one cross the *gloxiniæflora* parent had white flowers, there being no general purple colouration on the corolla, but the hybrid offspring was nevertheless distinctly purple, the intensity of colouration being determined as 16. Now, at a casual glance the flowers of the

lutea parent were without a purple tinge; but careful examination showed that at the base of the filaments, where attached to the corolla, there was a small, faint purple area. The yellow plant obviously brought some influence or factor into the hybrid rendering a purple colouration possible, since if the white *gloxiniæflora* had been crossed with another white plant of the same species all the offspring would have been white.

The general yellow colouration of *lutea* was transmitted considerably to the hybrid, but the purple colour masked it greatly.

In the intensity (34) of the purple colouration the hybrid was nearly midway between the two parents with mean intensities of 77 and 0 respectively. In spotting percentage the hybrid was only 5, and consequently in this character it was nearer to *lutea* with spotting 0 than to *gloxiniæflora* with mean spotting of 20. In the absolute length and breadth of the flower, and also in the ratio of these two dimensions the hybrid was closer to *gloxiniæflora* than to *lutea* (Pl. IV, fig. 2).

In *lutea* the lower lip exhibits no spotting, but it bears a characteristic marbled pattern in gamboge or brown. In the hybrid, faint traces of these brown marblings could generally be found, especially on the lateral, internal surfaces. In addition to this, the marbled pattern was frequently to some extent marked out in purple.

4. Hybrid (♀) × glox. (♂) and Hybrid (♀) × lutea (♂)—Backcrosses.

The hybrids were very sterile, and a microscopic examination showed that the pollen was very defective. Numerous flowers of different plants were pollinated with their own pollen, with pollen from other hybrids, and with pollen from *gloxiniæflora* and *lutea* plants. Several hundred pollinations were made. With self-fertilisation, or with pollen from other hybrids, the flower did not fall until faded, and the ovary grew but very little. Nevertheless even with such pollination the ovaries became somewhat more swollen than when no pollination had been attempted. With *gloxiniæflora* pollen, in the case of some of the hybrids, the flowers dropped quickly and the ovaries became greatly swollen. *Lutea* pollen acted still more energetically, and exceptionally large capsules were produced. In the case of all the hybrid plants, except in one, these capsules on ripening contained nothing but a few shrivelled seeds which seemed incapable of germination.† In one hybrid plant the pollen was found to be better in quality, judging from microscopical appearance, and in this plant only, out of the 32 plants, the majority of the capsules resulting from pollination with *lutea* and with *gloxiniæflora* pollen contained some seeds of fairly normal appearance. The seeds showed some varia-

† Note.—Subsequent investigation has shown that some of these seeds possessed the power of germinating and producing healthy seedlings. April, 1922.

bility in size, but there was no sharp dimorphism into large and small seeds, as seen in capsules resulting from the cross of *gloxiniæflora* (♀) with *lutea* (♂).

On this hybrid plant, 20 flowers were pollinated from *lutea*, and capsules developed; 3 of these capsules contained no good seed, while each of the remaining 17 bore on the average 14 good seeds of small size. On the same hybrid plant, 30 flowers were crossed with the pollen from several *gloxiniæflora* plants. Of the resulting capsules 9 contained no good seeds, while each of the remaining 21 bore on the average only 4 good seeds. Thus the cross, hybrid × *lutea*, was considerably more fertile than the cross, hybrid × *gloxiniæflora*. By "good" seed is meant unshrivelled seeds having a proper shape and stoutness, it does not necessarily mean that they were all capable of germination.

5. The Seeds of the Hybrid, obtained with glox. and lutea Pollen.

In identically the same hybrid plant the seeds obtained by using *gloxiniæflora* pollen differed distinctly in external appearance from those formed when *lutea* pollen was employed.

a. The testa was of a dark chestnut brown in seeds obtained with *gloxiniæflora* pollen, and of a yellow colour with *lutea* pollen. The distinction was not due to any difference in the character of the endosperm, for this was white in both.

b. The mean ratio, $\frac{\text{Breadth}}{\text{Length}} \times 1000$, of 81 seeds (from 10 capsules in all) with *gloxiniæflora* pollen was 628, and of 75 seeds (from 9 capsules in all) with *lutea* pollen was 578. This constitutes a well-marked difference readily detected by the eye (Pl. IV, fig. 1).

c. The cells of the testa were somewhat larger and had thicker walls with *gloxiniæflora* pollen than with *lutea* pollen, the difference in tangential diameter being about 9:8. The outer tangential wall of the testa cells usually disappeared entirely in seeds from the *gloxiniæflora* pollen, but a thin glistening lamina generally persisted in the seeds from *lutea* pollen (Pl. V, fig. 6, *p. o. w.*).

d. The hilum region of the seed projected on the average about 4 times more prominently beyond the general contour in seeds from *lutea* pollen than in those from *gloxiniæflora* pollen (Pl. IV, fig. 1).

In both kinds of seeds the dead tapetal layer immediately within the testa was of variable thickness, but was always more conspicuously developed than in the larger of the two sizes of seeds derived from the cross, *gloxiniæflora* and *lutea*. The general condition resembled that shown in Pl. V, fig. 5.

The question arises as to what interpretation is to be placed on the differences in the seed produced by the same plant under the action of the two kinds of pollen.

The mere act of pollination and the growth of the pollen tubes in the style obviously exert a stimulus on the mother-plant, and induce the fall of the flower and growth of the ovary.

After fertilisation, and when the development of the embryo and endosperm commences, a continued influence is exerted on the mother-tissue (cf. plant and animal galls), and it is of interest to enquire as to how far such an influence is specific and depends on the nature of the fertilisation. With *lutea* pollen the resulting mature seeds tended to have smaller integument cells, persistent outer cell-walls and lighter coloured cell-walls than when *gloxiniæflora* pollen was used. In these characters the backcross seeds tended to resemble ordinary *lutea* seeds or *gloxiniæflora* seeds according as to whether *lutea* pollen or *gloxiniæflora* pollen was used for fertilisation. The results obtained indicate a more specific influence being exerted by the growing embryo and endosperm on the mother-tissue than might have been expected. Such an influence is, of course, not heredity in any ordinary sense.

It might have been anticipated that the general size and shape of the backcross seeds would depend on the size and shape of the embryo and endosperm mass; but the shape of the seed produced by the cross, *gloxiniæflora* (♀) × *lutea* (♂) was not intermediate between the shapes of the seeds of the two species, and in fact it resembled neither. This was also the case in the seeds obtained by the backcross fertilisations. The differences in size and shape were perhaps mainly due to the fact that there was an arrest in the general growth of the seed owing to a cessation in the growth of the embryo and endosperm, resulting through uncongenial fertilisation. When such an arrest took place the growth of the integument tended always to exceed the requirements, and the formation of an internal space was prevented by the hypertrophy of the tapetal layer producing the peculiar compact tissue which occurred in all of the undersized seeds.

6. Gloxiniæflora (♀) × Hybrid (♂) and lutea (♀) × Hybrid (♂).

The pollen of the hybrid was tried on a considerable number of *gloxiniæflora* plants, but there was little response. In one case some 6 or 7 seeds were obtained in a capsule, and from these only one plant was raised. The cross between the fertile hybrid and *lutea* was tried, but no seeds were obtained.

It is clear that the cross between the hybrid as male and either original species as female was less easy to obtain than the cross with the hybrid as female and either species as male.

7. The Gametic Constitution of Hybrid and Backcrosses.

The hybrids were sterile with each other, and with their own pollen,* but with reference to the factorial hypothesis and the

—In the subsequent season more success has been attained in selfing hybrids. April, 1922.

segregation of factors, backcrosses with plants which are the immediate descendants of the parents which produced the hybrid itself should afford evidence as valuable as offspring obtained by self-fertilisation of the hybrid. The problem is, do the factors governing like characters in the two species really mingle and become alike in the hybrid, or do they remain different, so that either the *gloxiniæflora* (P) or the *lutea* (Y) type is transmitted?

The gametic nature of the hybrid, according to Mendelian theory, may be represented as PY, of *gloxiniæflora* as PP, and of *lutea* as YY. The question is, when the backcross, say, *hybrid* × *gloxiniæflora*, is made, do the factors P and Y in the hybrid remain distinct, or have they influenced each other, so that we have actually to do with a new factor resulting from their mutual influence? In the case of all the measurable characters dealt with it will be seen that the inheritance appears to have the nature of a blend.

On the crossing of the purple foxglove (♀) *gloxiniæflora* (PP), with the yellow species (♂) *lutea* (YY), the characters in the hybrid are often not intermediate in nature.

Leaves.—In the hybrid the ratio of breadth to length of the leaf is nearer to that of *gloxiniæflora* than to that of *lutea*: number of stomates nearer to *lutea*: hairiness nearer to *lutea*: rate of desiccation of plucked leaves nearer to *lutea*: size of epidermal cells, intermediate; length of stomates, intermediate; indentations, distinct from either (Pl. IV, fig. 2).

Flowers.—Absolute length and breadth of flower and ratio, nearer to *gloxiniæflora*; degree of spotting, nearer to *lutea* (Pl. IV, fig. 2); intensity of purple colouration, intermediate.

Thus out of 12 characters the hybrids were approximately intermediate in 3, nearer one parent or the other in 8, and different from either parent in 1.

Resembling one parent more strongly than the other in any given character is a common feature of interspecific hybrids, and it would be referred to as dominance by the Mendelians, and to prepotency by those who favour the view that a blend of homologous factors has occurred.

8. Comparison of Backcrosses with Hybrids and Parent Species.

Since only one hybrid plant was appreciably fertile, we are practically confined to the offspring arising from crossing this hybrid plant with both parent species. The only other backcross secured consisted of a single plant resulting from the pollination of a *gloxiniæflora* plant with the pollen of a second hybrid plant. This particular backcross has not yet flowered. It has the peculiarity of the leaves being very strongly coloured with purple. The colouration is due to the epidermal cells containing a bright purple sap. The edges of the leaves of normal *gloxiniæflora* are occasionally tinged with purple, but nothing approaching the condition of this backcross has ever been seen in either parent species.

By backcrossing a hybrid plant with both of the parent species, and examining a series of widely different characters in the offspring, it is considered that some evidence is obtainable as to the condition of the factors in the hybrid parent; that is to say, whether the two factors of an homologous pair have retained their differences unimpaired, so that on segregation occurring the characters would reappear in their original purity, or whether they have mutually influenced each other, or blended, to form a pair of similar factors which may or may not be intermediate in nature between the two original factors.

In order to see the bearing of the experiment on the problem, it is insufficient to deal simply with means; it is necessary to give the frequency distribution of variation in the form of tables which will show at a glance the range of variability in the different generations. In this place we will deal with a few of the characters which have been investigated.

Flower: Length of Corolla.—The length of the flower of *lutea* is very much less than in *gloxiniæflora*. In the hybrid the length tends to be nearer to that of *gloxiniæflora* (Pl. IV, fig. 2). The result of backcrossing the hybrid with the two parent species is shown in the accompanying table. The mean of the *gloxiniæflora* backcross (500) is much nearer to the *gloxiniæflora* mean (505) than to the hybrid mean (421), and the mean of *lutea* backcross (356) is nearer to the *lutea* mean (318) than to the hybrid mean (421).

Absolute Length of Corolla.

Grades of length in tenths of millimetre.	*Gloxiniæflora.*	*Backcross, hybrid* (♀) × *glox.* (♂)	*Hybrids, glox.* (♀) × *lutea* ♂	*Bockcross, hybrid* (♀) × *lutea* (♂)	*Lutea.*
	PP	PY × PP	PY	PY × YY	YY
230—269... ...	—	—	1	—	1
270—309... ...	—	—	1	—	4
310—349... ...	—	—	0	3	12
350—389... ...	—	—	3	6	1
390—429... ...	—	—	10	—	—
430—469... ...	2	1	13	—	—
470—509... ...	8	2	3	—	—
510—549... ...	5	0	—	—	—
550—589... ...	0	1	—	—	—
590—629... ...	1	—	—	—	—
Means	505	500	421	356	318

Supposing that corolla-length is controlled by one factor, or a group of connected factors, the gametic constitution, according to Mendelian theory, is given at the head of the columns.

Now, if the two homologous factors (P and Y) had remained unaltered in the hybrid, half of the offspring of the *lutea* backcross (5th column) should cluster about the hybrid mean (grade 390-429) and half about the *lutea* mean (grade 310-349), but there is no tendency for this condition. In the case of the backcross with *gloxiniæflora* (3rd column) the number of the plants is few, but there is no indication of a dimorphic series.

If it is supposed that corolla-length depends on two or more independent factors, results would be less simple, but in such case the backcrosses should, at least, exhibit very considerable variability, and reference to the table shows that the variation is remarkably small.

FLOWER: INTENSITY OF PURPLE COLOURATION.—The scale of colour intensity, which was employed, is the same as that previously described.[1]

In all the *lutea* plants used in the experiment the purple colouration was exceedingly slight, and was confined to a very inconspicuous patch at the base of the filaments of the stamens; but among some other *lutea* plants growing elsewhere, the inside of the base of the corolla was found to be distinctly purple, and the filaments were coloured along their whole length. The *gloxiniæflora* plants varied from quite pale purple to an intense purple. In the hybrids the mean intensity of colouration (34) was nearly intermediate between the means of the two parent species. The mean of the *gloxiniæflora* backcross (39) is very much nearer to the hybrid mean (34) than to the *gloxiniæflora* mean (82), but the mean of the *lutea* backcross (7) is much nearer to the *lutea* mean (5) than to the hybrid mean (34).

INTENSITY OF PURPLE COLOURATION.

Grades of colour-scale for Purple Colouration.	*Gloxiniæflora.*	*Backcross*, hybrid (♀) × *glox.* (♂)	*Hybrids*, *glox.* (♀) × *lutea* (♂)	*Backcross*, hybrid (♀) × *lutea* (♂)	*Lutea.*
	PP	PY × PP	PY	PY × YY	YY
0—9	—	—	2	7	17
10—19	—	—	1	2	—
20—29	1	—	5	—	—
30—39	0	2	17	—	—
40—49	0	2	3	—	—
50—59	2	—	4	—	—
60 —69	0	—	—	—	—
70—79	3	—	—	—	—
60—89	4	—	—	—	—
90—99	3	—	—	—	—
100—109	0	—	—	—	—
110—119	0	—	—	—	—
120—129	1	—	—	—	—
Means	82	39	34	7	5

(1) Loc. cit. "Biometrika," 1917.

Here there is not the least tendency for any dimorphism in the purple colouration of the two backcrosses (3rd and 5th columns), and the variability is remarkably small.

Such a simple character as the greater or lesser intensity of the same colour is likely to depend on some one factor, and, if the purity of the two homologous factors is to be supposed to remain unaffected by their contact in the hybrid, the backcrosses should exhibit a strongly marked dimorphic condition, but the experimental results show that the offspring are strikingly uniform.

If, on the other hand, colour intensity depends on several independent factors, the uniformity of the backcrosses militates against the supposition that the factors remain pure in the hybrid.

LEAF: PILOSITY.—The number of hairs that could be counted projecting over the edge of the leaf along a definite length (2 mm.) was taken as a general measure of the pilosity.

The leaves of *lutea* are markedly smooth, and bear but few hairs, while *gloxiniæflora* leaves are usually richly pilose. The mean of the pilosity (20) of the hybrids was slightly closer to the *lutea* mean (6) than to the *gloxiniæflora* mean (37). The mean of the *gloxiniæflora* backcross (19) is much nearer to the hybrid mean (20) than to the *glox.* mean (37), and the mean of the *lutea* backcross (12) is slightly nearer to the *lutea* mean (6) than to the hybrid mean (20).

PILOSITY OF LEAF.

Grades of number of hairs along 2 mm. of leaf-edge.	*Gloxiniæflora.*	*Backcross,* hybrid (♀) × *glox.* (♂)	*Hybrids,* *glox.* (♀) × *lutea* (♂)	*Backcross,* hybrid (♀) × *lutea* (♂)	*Lutea.*
	PP	PY × PP	PY	PY × PP	YY
0—4	—	—	—	3	9
5—9	—	—	3	8	12
10—14	—	2	4	6	4
15—19	1	3	10	3	1
20—24	3	3	5	1	—
25—29	3	1	3	1	—
30—34	3	—	1	1	—
35—39	5	—	2	—	
40—44	2	—	0	—	—
45—49	2	—	0	—	—
50—54	4	—	0	—	—
55—59	1	—	1	—	—
Means	37	19	20	12	6

It will be seen that in the backcross (3rd column) of the hybrid with *gloxiniæflora* none of the offspring approach the mean (grade 35-39) of *gloxiniæflora*. In the backcross (5th column) with *lutea* the condition cannot be so clearly observed on account of the fact

that the means of the hybrid and of *lutea* happen to be rather close together, but nevertheless even here the distribution of the backcross offspring indicates a homogeneous series.

LEAF: LENGTH OF GUARD-CELLS OF STOMATES.—The stomates of *lutea* are much larger than those of *gloxiniæflora*. The length of the guard-cells in the hybrids is very variable, and the mean (72) is intermediate between that of *lutea* (84) and that of *gloxiniæflora* (60). The variability exceeds that of either of the parent species. The mean of the *gloxiniæflora* backcross (71) is very much nearer to the hybrid mean (72) than to the *glox.* mean (60), and the mean of the *lutea* backcross (80) is much nearer to the *lutea* mean (84) than to the hybrid mean (72).

LENGTH OF GUARD-CELLS OF STOMATES OF LOWER SURFACE OF LEAF.

Grades of lengths in divisions (·0041 mm.) of ocular micrometer × 10	*Gloxiniæflora.*	*Backcross,* hybrid (♀) × *glox.* (♂)	*Hybrids,* *glox.* (♀) *lutea* (♂)	*Backcross,* hybrid (♀) × *lutea* (♂)	*Lutea.*
—	PP	PY × PP	PY	PY × YY	YY
50 53	—	—	1	—	—
54—57	5	—	1	—	—
58—61	13	1	2	—	—
62—65	6	0	5	—	—
66—69	2	2	3	1	—
70—73	—	6	1	3	2
74—77	—	0	1	7	1
78—81		2	4	3	4
82—85		—	3	2	9
86—89	—	—	0	1	7
90—93			1	1	1
94—97	—	—	1	3	0
98—101	—	—	—		1
Means	60	71	72	80	84

Reference to the 3rd column shows that there is no tendency for the offspring of the *gloxiniæflora* backcross to cluster around the mean of *gloxiniæflora* (grade 58-61). With the *lutea* backcross the condition is not clear on account of the fact that the hybrid backcross and *lutea* means are too close together.

LEAF: RATIO OF BREADTH TO LENGTH.—Relative to the length, the leaves of *lutea* tend to be very much narrower than those of *gloxiniæflora* (Pl. IV, fig. 2). In the hybrid the mean (244) of the ratios is closer to that of *gloxiniæflora* (285) than to that of *lutea* (160). The mean of the *glox.* backcross (297) is much nearer to the *glox.* mean (285) than to the hybrid mean (244), and the mean of the *lutea* backcross (181) is much nearer to the *lutea* mean (160) than to the hybrid mean (244).

$$\text{Leaf-ratio } \frac{\text{Breadth}}{\text{Length}} \times 1000.$$

Ratio Grades.	*Gloxiniæflora.*	*Backcross, hybrid* (♀) × *glox* (♂)	*Hybrids, glox.* (♀) × *lutea* (♂)	*Backcross, hybrid* (♀) × *lutea* (♂)	*Lutea.*
	PP	PY × PP	PY	PY × YY	YY
100—129... ...	—	—	—	3	4
130—159... ...	—	—	1	4	9
160—189... ...	—	1	1	5	11
190—219... ...	7	1	11	1	2
220—249... ...	17	0	8	3	1
350—279... ...	17	2	5	1	—
280—309... ...	13	2	1	1	—
310—339... ...	22	3	5	—	—
340- 369... ...	5	2	1	—	—
370—399... ...	3	1	—	—	—
400—429... ...	1	—	—	—	—
Means	285	297	244	181	160

If the leaf-ratio depends on a single factor, or a group of connected factors, and these factors remain unchanged in the hybrid, then in both backcrosses (3rd and 5th columns) a dimorphic condition of the offspring should be observable, but such is not the case. If the leaf-ratio depends on two or more independent factors which remain unchanged in the hybrid then much variability in the backcrosses would be expected, and the two series would have a heterogeneous aspect. An inspection of the table shows that the variability is not very large, and there is no evidence of heterogeneity.

In all the other characters studied (namely, in the leaf; size of lower epidermal cells, number of stomates, rate of desiccation of plucked leaves, and depth of indentations: and in the flower; breadth of corolla, ratio of breadth to length, and degree of spotting), there is likewise no indication of the offspring of the backcrosses being divisible into two sets, one resembling the hybrid parent, and the other, one of the parent species.

On the view that all these characters depend on a number of independent factors which remain pure in the hybrid, there should be, at least, a clearly marked exceptional variability of the backcrosses, but there is no suggestion of such in any of the characters dealt with.

9. Conclusions.

It is evident that the potentialities of an organism must depend on some qualities or powers of the fertilised egg. These

qualities or powers may be called factors, and the factorial hypothesis attempts to give some explanation of the nature and transmission of factors in sexual and asexual reproduction. Mendelism is merely a certain aspect of the factorial hypothesis, and one of the main points of dispute is, whether factors are to be generally regarded as essentially fixed and unchangeable, so that, when segregation occurs, the pure factor emerges uninfluenced by its former association with other factors or by the external environment. It is important to note that evidence has been recently brought forward by Professor Bateson indicating that segregation can occur in other cells than in germinal cells.

In a previous paper already cited the behaviour of crosses of varieties of a species was discussed, and it was shown that in all those characters capable of measurement which were examined the *degree* of development was inherited in self-fertilised generations, and, on crossing, a blend occurred in the offspring. The factors controlling these characters were also blended, since in subsequent generations raised by self-fertilisation there was no tendency for a reappearance of the grandparental characters in an unchanged condition.

A point of some interest may be mentioned. The peloric character of foxgloves, like the purple colouration, is inherited in a perfectly typical Mendelian fashion. But there are all degrees of pelorism, just as there are of colour intensity, and the inheritance of the *degree* of pelorism and of the intensity of colour is of the blended type. With blended inheritance, selection is effective in producing a gradual modification; but on account of the lack of sufficient variation combined with the drag of regression it may not always be possible to carry the modification to any great extreme.

By regression is meant the influence whereby exceptional parents tend to produce offspring which are more normal (that is closer to the mean of the race) than themselves. The existence of regression, in the sense in which Galton used the term, as the drag of the back ancestry, has been denied by some. It is stated by Babcock and Clausen[1] "this regression is not due to the pull of a back ancestry; it is due to the fact that *individuals whose somatic appearance places them in diverse classes in the frequency distribution are themselves gametically different and will breed differently.*"

The statement in italics is doubtless true, and the breeding differently is due to the factors being different, arising from the fact that the powers of any individual factor in producing a somatic character must depend on the constitution of that factor, and the particular nature of any individual factor is the result of its past history which involves the back ancestry.

Such a view is not compatible with the assumption of discrete and relatively unchangeable factors, and hence is rejected by the

---

[1] Babock, E. B., and Clausen, R. E. "Genetics in relation to Agriculture," 1918, p. 55.

strict Mendelian; but it follows naturally on the conception of factors capable of being gradually modified by the influence of other factors and perhaps also by the external environment.

In the case of the peloric condition of foxgloves, starting with homozygous plants in which this character was quite definitely present, it has been possible by selection of self-fertilised generations to eliminate the character altogether. A similar result was reached, but with much greater difficulty, in obtaining a white foxglove by the selection of self-fertilised generations of homozygous, pale mauve plants. Quantity of a character being inherited by the blending type, and selection being effective, it is sometimes possible to eliminate a character altogether, and the point of contact between Mendelian and blending inheritance is reached.

These results indicate a gradual change in the nature of the factor or factors governing a blending character, and the change can arise through crossing, the homologous factors mutually influencing each other.

In the present paper distinct species are dealt with having very marked specific differences. The character in the interspecific hybrid may be intermediate or considerably nearer to one species or the other, and thus dominance or prepotency may be exhibited. Similarly in the backcrosses the character may be intermediate or much nearer either to the hybrid parent or to the pure species parent.

On account of sterility, raising offspring by self-fertilisation of the hybrid was not possible; but for testing the theory of segregation and the persistence of the purity of factors, backcrosses are equally useful. In all the measurable characters examined there was no clear reappearance in the backcrosses of the grandparental characters in an uncontaminated condition. The view that these results are due in every case to the existence of multiple, independent, unchangeable factors would be only justified if the backcross offspring exhibited exceptional variability, but such is not the case. Thus the results obtained with interspecific hybrids resemble those found with intervarietal hybrids.

The conception of the segregation of factors in the division of cells is useful, provided it is not demanded by the Mendelians that these factors shall necessarily have any fixed or invariable nature. In most ordinary, measurable characters the factors on crossing would seem to blend, and although the blend may not necessarily entail an intermediate condition of the character, yet the factors, or connected group of factors, are changed by the crossing, and a reappearance of the pure character is not to be expected, and would only result by the production of a new factor, and not by the persistenec of the original, unchanged one.

Explanation of Plates.

Plate IV.

Fig. 1.—*Glox.* pollinated with *lutea* yielded dimorphic seeds (large to small about 1 : 75 in number) both capable of germina-

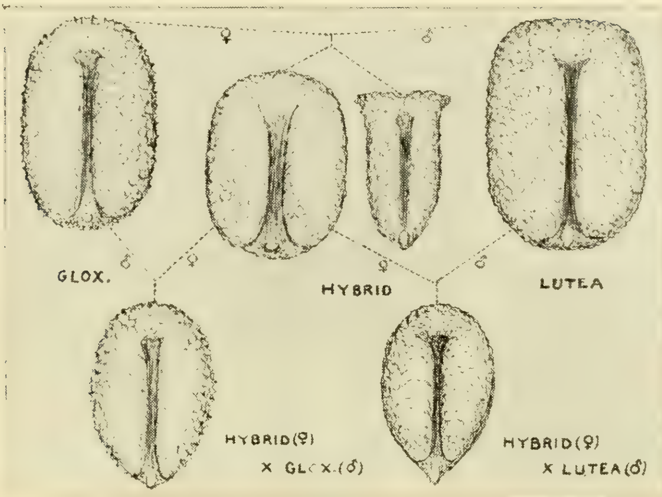


FIG. 1.

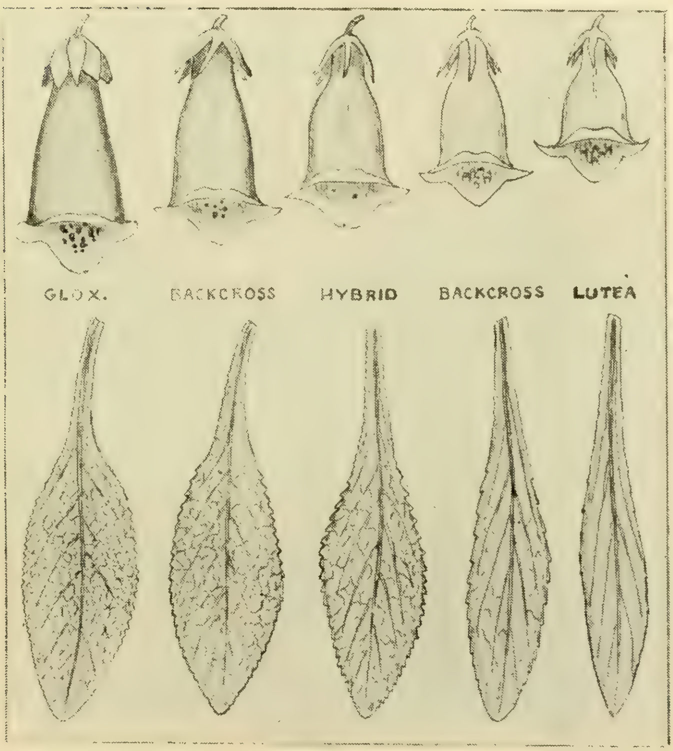
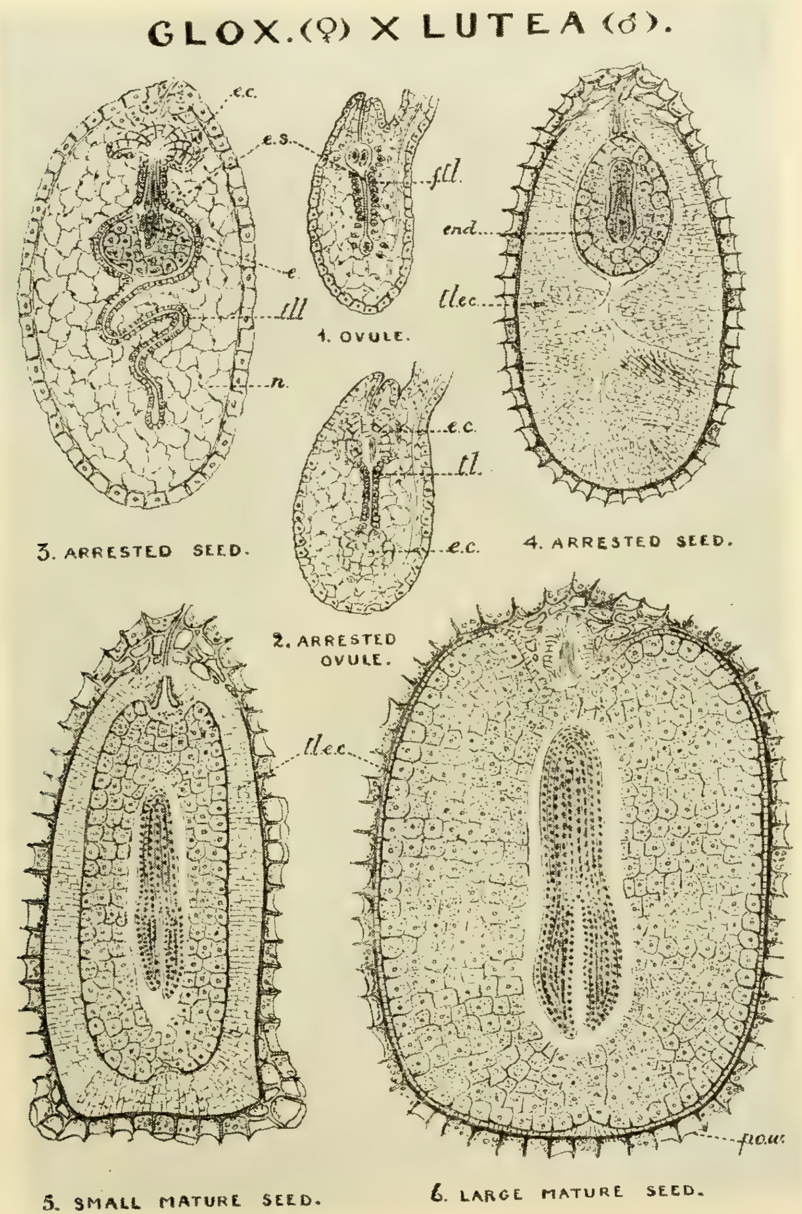


FIG. 2.

HYBRID DIGITALIS.



HYBRID DIGITALIS.

tion. The seed produced by *glox.* pollen on a hybrid plant differed markedly in shape (see bottom two figures) from the seed formed with *lutea* pollen on the same, identical hybrid plant. Drawn to scale.

Fig. 2.—Typical leaves of the various generations; taken of the same length, and showing the differences in the mean widths, indentations and general veining.

Typical flowers of the same generations, showing the differences in the shape of the calyx, and in the length, breadth, spotting and marbling of the corolla. Drawn to scale.

PLATE V.

Longitudinal sections of ovules and seeds; *glox.* fertilised with *lutea* pollen. In all the figures, except in fig. 1, the power of further growth had ceased.

e. Embryo. *end.* Endosperm. *e.c.* Empty cells of nucellus. *e.s.* Embryo-sac. *f.t.l.* Formation of tapetal layer. *n.* Nucellus. *p.o.w.* Persistent outer wall of testa cell. *t.l.* Tapetal layer. *t.l.l.* Tapetal layer still living. *t.l.e.c.* Hypertrophied tapetal layer of empty cells.

SOME PROTOZOA FOUND IN CERTAIN SOUTH AFRICAN SOILS.—I.

BY

H. B. FANTHAM, M.A., D.Sc., and ESTHER TAYLOR, M.Sc.,

Department of Zoology, University of the Witwatersrand, Johannesburg.

Read July 15, 1921.

INTRODUCTION.

The Protozoa are a large and important group of organisms, which are widely distributed. Many inhabit fresh water, occurring in ponds and ditches and in infusions exposed to the air. Some Protozoa are marine. The parasitic Protozoa have been widely studied in connection with various diseases in man and other animals. Free-living Protozoa inhabiting the soil have recently received attention, and it is their relation to soil bacteria and the possible bearing on soil fertility which has been chiefly investigated by the few workers who have given direct attention to the subject.

Russell and Hutchinson (1909, 1913), working at Rothamsted Experimental Station, England, were among the first to consider the relation of Protozoa to bacteria and to fertility, using the method of partial sterilisation of the soil. Such partial sterilisation may be attained by heat, and by the addition of toluene or carbon bisulphide to the soil. Partially sterilised soil was found to be more productive than untreated soil, but the effects produced

by partial sterilisation are complex, as several factors are operating simultaneously. The existing bacterial equilibrium of the soil seems to be disturbed by such treatment. Russell and Hutchinson considered that untreated soil contained a factor, not bacterial, limiting the development of bacteria, which factor was inhibited by antiseptics or heat. This limiting factor was then presumed to be the Protozoa in the soil, and so arose the "protozoan theory of soil fertility." However, the original contention of Russell that Protozoa limit the number of bacteria in the soil cannot yet be considered as proved, as a crucial test is still wanting. Russell and Hutchinson also thought that excessive numbers of Protozoa in soil may be the cause of "soil sickness."

Regarding work actually done already on soil Protozoa, it seems almost impossible to make definite general statements. Martin and Lewin worked on the subject in England especially about the time of the beginning of the Great War, to be precise, during the period 1912 to 1915. Goodey (1911-1916) published some results obtained from work done at Rothamsted. Cutler is a still more recent worker there. In the United States, Kopeloff and Coleman (1917) published an interesting review on soil Protozoa and soil sterilisation, while Fellers and Allison (1920) recorded results from studies on New Jersey soils. Again, Cunningham (1915), working at Leipzig, published some results on the relations between soil Protozoa and bacteria in laboratory cultures. From the observations of these authors it seems that the majority of Protozoa ordinarily occur in the soil in the encysted state. They would need to be often active to destroy bacteria. As to culture solutions, the conditions therein are different from those found in the soil, as was suggested by Martin. Koch (1915) states that "it is probable that the results produced by adding the soil to tap water more nearly represent the conditions as they are found in the soil." Koch also states that "the development of soil Protozoa in artificial culture solutions varies with the kind of media employed."

From the foregoing it will be seen that many views are prevalent in respect to the relation of soil Protozoa to their environment, and that much more work is necessary before final conclusions can be obtained. Also, it is highly probable that it will not be possible to generalise regarding soil Protozoa for the whole world, there being too many varying factors concerned.

Material and Methods.

An endeavour has been made by the present writers to ascertain and briefly describe the Protozoa found associated with various types of South African soils. Observations at the present stage of the investigation have been of necessity largely confined to living material. The present is the first attempt to investigate soil Protozoa in South Africa, and so must, of necessity, be preliminary in character.

Representative soils were collected from sugar and banana plantations, vineyards, orchards, gardens, agricultural plots, moun-

tains, and various other sites. Cultivated, uncultivated and virgin soils were examined and compared, and their acidity tested in each case by the litmus compression method.

Samples of soil were taken from three inches to twelve inches deep and the soil collected in some cases from the bottom of the hole, in other cases from the sides, the latter case yielding "mixed" samples containing all the layers down to the required depth. Metallic diggers and sterilised containers were used, thus avoiding contamination from outside. The season and prevailing weather conditions were noted. A few samples of waterlogged soils have also been examined by direct observation. Some of these water-logged soils formed the basins of shallow pools or vleis, while others were taken from the banks of running streams.

Various culture media for soil Protozoa have been tried elsewhere, but none has been found perfectly satisfactory. In South Africa various media have also been tried, but the best results were obtained by using boiled, neutral tap water to ensure sterility, adding it to soils in definite proportions (for example, in some cases 1 gram of soil to 12 cc. of water, in other cases 1 gram of soil to 5 c.c. of water), and allowing it to stand for some time in test-tubes plugged with cotton wool, using ordinary bacteriological precautions to prevent contamination both at the time of incubation and during the periodical examinations. Samples of the water cultures were examined fresh by means of cover-slip or hanging drop preparations. The cultures were kept at room temperature in most cases. Some, however, were placed in incubators kept at 37°C. and 45°C. Some cultures were kept in the light, while others were placed in the dark. All the results accruing were compared. We know that water cultures may not give an accurate impression of the constitution of the active fauna of the soil, as excystation is brought about. However, this may be partly corrected by the comparative examination of specimens of naturally water-logged soil.

Determination of the approximate number of protozoan cysts in soils was attempted in some cases, and the intimate attachment of the cysts to the soil particles was demonstrated by successive triturations of the same sample of soil in boiled water and counting the number of cysts recognisable under the microscope after each trituration.

In every case the soil was examined previous to culture for Protozoa by microscopic examination of a small portion of soil in a drop of cold boiled water. Trophic Protozoa were rarely found, but encysted forms were fairly often recognised.

The use of fixatives and stains has been found difficult by most workers as distortion is easily caused in the Protozoa. Picric alcohol was a useful fixative. Methyl green proved a good stain for observing the nuclei of ciliates. Acid carmine and haematoxylin were useful general stains. As before stated, examination has so far been chiefly limited to fresh material.

Daily observations on the culture tubes were essential, as each organism appears to increase in numbers to a maximum, then

gradually to decrease and disappear as motile forms, often to reappear later. Periodicity is thereby indicated.

The determination of some of the Protozoa has been difficult, especially with the somewhat restricted literature at our disposal in South Africa.

The Protozoa Found in Certain South African Soils.

The results of our observations of the Protozoa found in water cultures of different South African soils may now be given. Soil samples from the Western and Eastern Cape Province, the Transvaal and Natal, have provided the bulk of the material hitherto. It will be convenient to deal with the soils under two groups: (*a*) Ordinary (non-waterlogged) soils under degrees of cultivation ranging from virgin soil to heavily cultivated sugar and vine land; and (*b*) soils that were waterlogged at the time of examination.

(*A*) Results of Examination of Various Ordinary (Non-waterlogged) Soils.

The soils here considered may be grouped as Cape Province, Transvaal and Natal soils.

I. Cape Province Soils.

Western Province soils were collected at St. James, Somerset Strand, Stellenbosch, Heathfield, High Constantia, Simonstown, Bellville and Rosebank Experimental Station, near Capetown; while soil from Kimberley was examined as representing Griqualand. With regard to Eastern Province soils, specimens from Port Elizabeth, Grahamstown and Grootfontein School of Agriculture have been studied.

St. James.—The soil was collected from the foot of the mountain on 23rd January, 1921, during fine weather. The sample was taken from a depth of about six inches. It was a dark-greyish soil containing some sea-sand, and gave a feebly alkaline reaction to litmus compression tests. On culture the following Protozoa were obtained:—

Rhizopoda.—*Amoeba proteus*, *A. limax*, *A. radiosa*, *A. verrucosa*, *A. guttula*, *Difflugia pyriformis*, *D. globulosa*.

Mastigophora.—*Mastigamoeba sp.*, *Oikomonas* (*Monas*) *termo*, *Pleuromonas jaculans*.

Heliozoa.—*Actinophrys sol*.

Infusoria.—*Holophrya ovum*, *Pleuronema chrysalis*, *Cyclidium glaucoma*, *Oxytricha pellionella*, *Vorticella campanula*, *Lacrymaria olor*, *Colpoda cucullus*, *Paramoecium aurelia*.

Somerset Strand. — The soil was sandy and was collected on 8th December, 1920, during hot weather, from a flower garden at a depth of six inches. Its reaction to litmus was feebly alkaline. In water culture it yielded:—

Rhizopoda.—*Amoeba proteus.*
Mastigophora.—*Peranema trichophorum, Euglena viridis.*
Infusoria.—*Pleuronema chrysalis, Cyclidium glaucoma, Oxytricha pellionella, Euplotes harpa, Paramoecium aurelia.*

Rosebank Experimental Station. — The soil was cultivated black, sandy, Liesbeek alluvial loam, collected on 21st June, 1921, in fine cold weather, and was a mixed sample of all the layers from the surface to one foot deep. It gave a feebly acid reaction. In water culture the Protozoa obtained were:—

Rhizopoda.—*Amoeba proteus, A. radiosa.*
Heliozoa.—*Actinophrys sol.*
Mastigophora.—*Cercomonas crassicauda.*

No Ciliata were obtained in this culture.

Bellville. — The sample was virgin sandy soil collected on 11th January, 1921, at a depth of five to six inches, during slight rain. It gave an acid reaction to litmus. The following Protozoa were obtained from it in water culture:—

Rhizopoda.—*Amoeba radiosa, Amoeba* spp., *Difflugia pyriformis.*
Mastigophora.—*Peranema trichophorum, Euglena viridis, Cercomonas crassicauda.*
Infusoria.—*Cyclidium glaucoma, Paramoecium aurelia, Oxytricha pellionella, Euplotes harpa.*

Heathfield. — The sample was taken six inches from the surface of uncultivated (but apparently fertile) soil, about thirty feet from the banks of a shallow ditch. The soil was collected on 11th October, in fine weather. It was blackish, with a slight mixture of grass roots. Arum lilies were growing in profusion in the vicinity. The reaction of the soil to litmus was alkaline. The following Protozoa were obtained in water culture:—

Rhizopoda.—*Amoeba proteus, A. limax, A. guttula, A. radiosa, A. verrucosa, Difflugia globulosa, D. pyriformis, Euglypha sp.**
Heliozoa.—*Actinophrys sol, Acanthocystis aculeata, Nuclearia simplex*† (a small form).
Mastigophora.—*Peranema trichophorum, Euglena viridis, Oikomonas* (*Monas*) *termo, Bodo* (*Prowazekia*) *parva* or *terricola*,‡ *Pleuromonas jaculans.*
Infusoria.—*Cyclidium glaucoma, Stylonychia mytilus.*

High Constantia. — The sample was taken at a depth of nine inches from the surface, and was a light-brown, readily crumbling soft soil, under cultivation with the best Hermitage grapes, used

* This species of Euglypha has not quite the same shell patterning as *E alveolata*, and somewhat resembles the form described by Martin and Lewin.

† This genus is som times placed with the Proteomyxa.

‡ The determination of this species is difficult, with the restricted literature at our disposal. It appears to be either *B. parva* or B. *terricola.*

for the production of Vlakkenberg wines. The waters in the neighbourhood are radio-active. The sample was collected on 14th October, in fine weather. Its reaction to litmus was acid. The water culture showed:—

Rhizopoda.—*Amoeba proteus*, Binucleate amoeba cyst.
Mastigophora.—*Oikomonas termo*, *Bodo* (*Prowazekia*) *parva*, *Euglena viridis*, *Pleuromonas jaculans*.

Infuscria.—*Cyclidium glaucoma*, *Lacrymaria olor*..

The organisms in this culture were always very few in number. It is possible that the known radio-active character of the water of the locality has some action inimical to Protozoa.

Simonstown. — The specimen was collected from uncultivated soil at Seaforth, Simonstown, during fine, hot weather, on 8th January. The soil was brownish and sandy, about fifty feet above sea level. The sample was taken from a depth of about six inches. Its reaction to litmus was acid. Ericas were growing near by. Water cultures yielded the following Protozoa:—

Rhizopoda.—*Amoeba limax*, *A. radiosa*, *A. guttula*, *Difflugia globulosa*, *Hyalosphenia elegans*, *Euglypha sp.*
Heliozoa.—*Actinophrys sol*, *Acanthocystis aculeata*.
Mastigophora.—*Mastigamoeba sp.*, *Peranema trichophorum*, *Oikomonas* (*Monas*) *termo*, *Bodo* (*Prowazekia*) *parva*, *Euglena viridis*, *Pleuromonas jaculans*.

Infusoria.—*Cyclidium glaucoma*, *Lacrymaria olor*.

A few Vibrios were found in this culture, and Mastigamoebae containing ingested bacteria were also observed.

Stellenbosch. — The specimen of soil was collected from a furrow in a newly-ploughed and planted vineyard, about six inches from the surface. It was a sandy, greyish-red soil, with a few shreds of plant roots, and was obtained on 12th October in fine warm weather. It gave an acid reaction to litmus. The following Protozoa were obtained in water culture:—

Rhizopoda.—*Amoeba proteus*, *A. limax*, *A. guttula*, *A. verrucosa*, *Pelomyxa palustris*, *Difflugia globulosa*, *D. pyriformis*, *Hyalosphenia elegans*, *Euglypha alveolata*. *Euglypha sp.*
Heliozoa.—*Actinophrys sol*.
Mastigophora.—*Mastigamoeba sp.*, *Peranema trichophorum*, *Oikomonas* (*Monas*) *termo*, *Bodo* (*Prowazekia*) *parva*, *Euglena viridis*, *Pleuromonas jaculans*.
Infusoria.—*Cyclidium glaucoma*, *Colpoda cucullus*, *Lacrymaria olor*, *Paramoecium aurelia*, *Stylonychia mitylus*.

Cultures of this soil also contained a few bacteria, mostly vibrios, and specimens of *Colpoda cucullus* and of *Pelomyxa* were found containing ingested vibrios

Kimberley. — This specimen was a reddish-brown sandy loam and was collected from an orange grove on 31st July, in fairly

warm weather. It contained soil from the surface to nine inches deep. Its reaction was feebly alkaline. The following Protozoa were obtained in water culture:—

Rhizopoda.—*Amoeba proteus.*
Infusoria.—*Cyclidium glaucoma*

Port Elizabeth. — Samples of soil were obtained from two sites, namely, the Museum Gardens and St. George's Park, during bright, warm weather. Their reactions were feebly acid.

(*i*) The Museum Gardens specimen was collected on 5th May, 1921, at a depth of six inches from the surface. On culture it yielded:—

Rhizopoda.—*Amoeba proteus, A. radiosa, Amoeba sp.*
Heliozoa.—*Actinophrys sol.*
Infusoria.—*Paramoecium aurelia, Cyclidium glaucoma.*

(*ii*) The St. George's Park specimen was collected on 5th May, 1921, at a depth of three inches from the surface. It was relatively uncultivated soil. On water culture it yielded:—

Rhizopoda.—*Amoeba proteus, A. radiosa.*
Iufusoria.—*Oxytricha pellionella.*

The two specimens of soil from Port Elizabeth are of interest as showing difference of protozoal fauna in areas relatively near to one another.

Grahamstown. — The sample of soil was uncultivated Witberg sand, under rough grass, and was taken at about a depth of one foot from the surface. It was collected near the Albany Museum on 21st September, in the afternoon, during slight rain. Its reaction was feebly acid. In water culture the Protozoa were:—

Mastigophora.—*Euglena oxyuris.*
Infusoria.—*Coleps hirtus, Paramoecium putrinum.*

Grootfontein School of Agriculture, Middelburg, C.P. — Two samples of Red Karroo soil were obtained on 29th September, namely, virgin Red Karroo and cultivated Red Karroo. Both samples were taken at a depth of six inches, and were feebly alkaline in reaction. The following Protozoa were obtained in water culture:—

(*i*) Virgin Red Karroo.
Rhizopoda.—*Amoeba limax, Difflugia globulosa.*
Mastigophora.—*Oikomonas termo, Bodo (Prowazekia), terricola* or *parva, Euglena viridis.*
Infusoria.—*Lacrymaria olor.*

(*ii*) Cultivated Red Karroo.
Heliozoa.—*Actinophrys sol.*
Mastigophora.—*Oikomonas (Monas) termo, Euglena viridis, Bodo (Prowazekia) parva.*
Infusoria.—*Lacrymaria olor, Colpoda steinii* or *saprophila,* Spirostomum ambiguum.*

The difference in protozoal fauna between virgin and cultivated Red Karroo sandstone soils is noticeable. Variations in the genera

* The species could not be determined with certainty from our available literature.

of Sarcodina are observed, amoebae and thecamoebae being present in virgin Red Karroo soil and absent from similar but cultivated soil. Mastigophora are constant. Cultivation appears to have caused an increase in the number of genera of Ciliata observed. Further observations are needed on these points.

II. Transvaal Soils.

Examination of normal (non-waterlogged) soils of the Transvaal has been confined to samples of cultivated ground from Johannesburg (Houghton Estate), to soils from the Veterinary Research Laboratory, Onderstepoort, near Pretoria, and to samples from Potchefstroom Agricultural College.

Johannesburg, Houghton Estate. The soil examined was red loam under cultivation as a flower and vegetable garden. It was collected on 15th April, 1921, and was a mixed sample of all the layers to nine inches deep. It gave an acid reaction to litmus. On culture the following Protozoa were obtained:—

Rhizopoda.—*Amoeba proteus*, *A. limax*.

Mastigophora.—*Bodo gracilis*, *Bodo* (*Prowazekia*) *parva*.

Onderstepoort. — Two samples of soil from the neighbourhood of the Veterinary Research Laboratory were obtained on different occasions.

(*i*) Black surface soil from near Laboratory Siding was collected during rain on 22nd March, 1921. It was fallow at the time. Its reaction to litmus was feebly acid. The water culture yielded:—

Mastigophora.—*Peranema trichophorum*, *Euglena viridis*, *Oikomonos* (*Monas*) *termo*, *Cercomonas crassicauda*.

Infusoria.—*Holophrya ovum*, *Colpidium colpoda*, *C. striatum*, *Colpoda cucullus*, *C. steinii* or *saprophila*, *Paramoecium aurelia*, *Cyclidium glaucoma*.

(*ii*) Black soil from near the hostels, Onderstepoort, a dripping tap being in the neighbourhood, was collected on 19th April, 1921. The sample was taken from near the surface and contained some grass roots. It was feebly acid in reaction. The following Protozoa were obtained in water culture:—

Rhizopoda.—*Amoeba gruberi* (also called *Nägleria gruberi*).

Mastigophora.—*Euglena oxyuris*, *Oikomonas* (*Monas*) *termo*, *Cercomonas crassicauda*.

Infusoria.—*Colpoda cucullus*, *Cyclidium glaucoma*, *Paramoecium aurelia*, *P. caudatum*.

Potchefstroom. — Samples of soil were obtained from the Agricultural College, Potchefstroom, on 26th September, during fine weather. All the samples consisted of layers of soil to six inches deep, and were acid in reaction to litmus. Three of the samples were examined by water culture for Protozoa.

(*i*) Cultivated fallow, field sample. The organisms found were:—

Rhizopoda.—*Amoeba limax*.

Mastigophora.—*Oikomonas termo*, *Bodo* (*Prowazekia*) *parva*.

Infusoria.—*Lacrymaria olor*, *Colpoda cucullus*.

(*ii*) Cultivated fallow, sample kept in a pot in a field. On culture it yielded:—

Mastigophora.—*Euglena viridis*, *Bodo* (*Prowazekia*) *parva*

Infusoria.—*Colpoda cucullus*.

(*iii*) Uncultivated fallow, kept in a pot in a field. On water culture the following Protozoa were observed:—

Mastigophora.—*Euglena viridis*, *Bodo* (*Prowazekia*) *parva*.

Infusoria.—*Colpoda cucullus*.

III Natal Soils.

Samples of soil from sugar and banana growing districts near Durban, from Cedara Agricultural College and from Durban Botanic Gardens were examined.

Umgeni. — This sample was described as "good sugar soil" and was bearing a heavy crop of young sugar cane when the specimen was collected, on 22nd April, 1921, slight rain falling at the time The specimen was a rather heavy, dark loam, and was taken at about twelve inches from the surface. Its reaction to litmus was acid. In water culture the following organisms were obtained:—

Heliozoa.—*Actinophrys sol*.

Mastigophora.—*Mastigamoeba*, *Bodo* (*Prowazekia*) *parva*, Euglenoids, *Cercomonas crassicauda*.

Infusoria.—*Paramoecium aurelia*, *Cyclidium glaucoma*, *Pleuronema chrysalis*, *Spirostomum ambiguum*, *Euplotes patella*, *Euplotes harpa*, *Vorticella campanula*.

Sydenham. — This soil was a somewhat tenacious loam bearing a good crop of sugar cane, the sugar being described as of a "good medium grain." The sample was collected as a mixed sample of all the layers to about twelve inches deep, on 24th April, 1921, the day being very hot. The soil was slightly damper than that obtained from Umgeni. Its reaction to litmus was acid. In water culture it yielded:—

Mastigophora.—*Mastigamoeba*, *Bodo* (*Prowazekia*) *parva*, *Oikomonas* (*Monas*) *termo*, *Cercomonas crassicauda*, Euglenoids.

Infusoria.—*Colpoda cucullus*, *Colpidium striatum*, *Cyclidium glaucoma*, *Oxytricha pellionella*, *Euplotes harpa*.

Mayville. — This sample was of reddish loam mixed with a small amount of sand, and was obtained from a well-irrigated banana plantation on 24th April, 1921, on a very hot day. Its reaction to litmus was feebly acid. The Protozoa obtained in culture were:—

Mastigophora.—*Bodo* (*Prowazekia*) *parva*, *Oikomonas* (*Monas*) *termo*, *Euglena oxyuris*, Euglenoids.

Infusoria.—*Paramoecium aurelia*, *Paramoecium putrinum*, *Cyclidium glaucoma*.

Cedara.— Three samples of soil from Cedara Agricultural College were examined in water culture.

(*i*) Black vlei soil, obtained near Cedara Station, the sample comprising all the layers to a depth of nine inches below the surface. It was collected during rain on 3rd October. Its reaction to litmus was acid. In water culture the following Protozoa were obtained:—

Mastigophora.—*Oikomonas* (*Monas*) *termo*.

Infusoria.—*Paramoecium aurelia*, *Stylonychia mytilus*, *Euplotes harpa*, *Euplotes patella*.

(*ii*) Dolerite soil under cultivation, from the experimental plot at the School of Agriculture. This was a mixed sample of all the layers to nine inches from the surface and was collected on 3rd October, during rain. Its reaction to litmus was acid. The following Protozoa were found in water culture:—

Rhizopoda.—*Amoeba limax*.

Mastigophora.—*Oikomonos termo*, *Bodo* (*Prowazekia*) *parva*, *Euglena viridis*.

Infusoria.—*Holophrya ovum*, *Colpoda cucullus*, *Cyclidium glaucoma*.

(*iii*) Dolerite soil, uncultivated, obtained near the tennis court of the School of Agriculture, about nine inches from the surface, on 3rd October, during rain. It gave an acid reaction to litmus. The following Protozoa were found in water cultures:—

Rhizopoda.—*Amoeba limax*, *Amoeba sp.* with tetranucleate cyst.

Mastigophora.—*Oikomonas* (*Monas*) *termo*, *Bodo* (*Prowazekia*) *parva*.

Infusoria.—*Colpoda cucullus*, *Cyclidium glaucoma*.

It may be noted that a greater variety of Protozoa occurred in water cultures of cultivated as compared with uncultivated dolerite soil, more especially among Infusoria. Black vlei soil here yielded Protozoa not found in the dolerite soils.

Durban Botanic Gardens. — This was a mixed sample of soil containing some sand collected under a mango tree, and consisted of all the layers of soil from the surface to twelve inches deep. It was collected on 21st September, on a hot day. Its reaction to litmus was acid.

In water culture, one organism only was obtained, the Heliozoon, *Actinophrys sol*, which was fairly numerous for a few days.

Geographical Distribution.

The geographical distribution of the different species of Protozoa found up to the present may be summarised thus:—

Rhizopoda.

Amoeba proteus, found at St. James, Somerset Strand, Heathfield, Stellenbosch, Rosebank, Bellville, Port Elizabeth (Museum Gardens and St. George's Park), Kimberley, Grootfontein (virgin Red Karroo), Johannesburg, Umgeni.

Amoeba limax, found at St. James, Heathfield, Simonstown, Stellenbosch, Grootfontein, Johannesburg, Potchefstroom, Cedara (cultivated dolerite soil).

Amoeba radiosa, found at Bellville, Rosebank, Heathfield, Simonstown, Port Elizabeth (Museum Gardens, St. George's Park).

Amoeba guttula, found at St. James, Heathfield, Simonstown, Stellenbosch.

Amoeba (*Nägleria*) *gruberi*, found at Onderstepoort near the hostels.

Amoeba sp., with tetranucleate cyst, found at Cedara (uncultivated dolerite soil).

Difflugia pyriformis, found at St. James, Bellville, Stellenbosch.

Difflugia globulosa, found at St. James, Simonstown, Grootfontein (virgin Red Karroo).

Hyalosphenia elegans, found at Simonstown, Stellenbosch.

Euglypha alveolata, found at Heathfield; *Euglypha sp.*, at Heathfield, Simonstown, Stellenbosch.

Heliozoa.

Actinophrys sol, found at St. James, Rosebank, Heathfield, Simonstown, Stellenbosch, Port Elizabeth (Museum Gardens), Grootfontein, Durban Botanic Gardens, Umgeni.

Acanthocystis aculeata, found at Heathfield, Simonstown.

Nuclearia simplex, found at Heathfield.

Mastigophora.

Mastigamoeba, found at St. James, Simonstown, Umgeni, Sydenham.

Peranema trichophorum, found at Somerset Strand, Bellville, Heathfield, Simonstown, Stellenbosch, Onderstepoort.

Euglena oxyuris, found at Grahamstown, Onderstepoort (near hostels), Mayville.

Euglena viridis, found at Somerset Strand, Bellville, Heathfield, Stellenbosch, Simonstown, High Constantia, Grootfontein (virgin and cultivated Karroo), Onderstepoort (Laboratory Siding), Potchefstroom.

Euglenoids, found at Umgeni, Mayville, Sydenham.

Oikomonas (*Monas*) *termo*, found at St. James, Heathfield, Simonstown, Stellenbosch, High Constantia, Grootfontein, Onderstepoort (near hostels), Potchefstroom, Cedara (dolerite), Sydenham.

Cercomonas crassicauda, found at Bellville, Rosebank, Onderstepoort (near Siding and hostels), Umgeni, Sydenham.

Bodo (Prowazekia) parva, found at Grootfontein (virgin Red Karroo), Potchefstroom, Umgeni, Sydenham, Mayville, Cedara.

Bodo gracilis, found at Johannesburg (Houghton Estate).

Pleuromonas jaculans, found at St. James, Heathfield, Simonstown, Stellenbosch, High Constantia.

Infusoria.

Holophrya ovum, found at St. James, Onderstepoort (near Laboratory Siding), Cedara (cultivated dolerite).

Lacrymaria olor, found at St. James, Simonstown, Stellenbosch, High Constantia, Grootfontein (virgin and cultivated Red Karroo), Potchefstroom.

Coleps hirtus, found at Grahamstown (Witberg sand).

Colpidium colpoda, found at Cedara (uncultivated dolerite).

Colpidium striatum, found at Potchefstroom, Onderstepoort (Laboratory Siding), Sydenham.

Colpoda cucullus, found at St. James, Stellenbosch, Potchefstroom, Onderstepoort (near hostels and Laboratory Siding), Cedara (cultivated dolerite), Sydenham.

Colpoda saprophila or *steinii*, found at Onderstepoort (Laboratory Siding), Grootfontein.

Paramoecium aurelia, found at St. James, Bellville, Somerset Strand. Stellenbosch, Port Elizabeth (Museum Gardens), Onderstepoort (near Laboratory Siding and hostels), Umgeni, Mayville, Cedara (black vlei).

Paramoecium caudatum, found at Onderstepoort (near hostels).

Paramoecium putrinum, found at Grahamstown, Mayville.

Pleuronema chrysalis, found at St. James, Somerset Strand, Onderstepoort, Sydenham, Umgeni.

Cyclidium glaucoma, found at Bellville, Somerset Strand, Kimberley, Port Elizabeth (Museum Gardens), Onderstepoort (near Laboratory Siding and hostels), Cedara (uncultivated dolerite), Umgeni, Sydenham, Mayville.

Spirostomum ambiguum, found at Grootfontein (cultivated Red Karroo), Umgeni.

Oxytricha pellionella, found at St. James, Somerset Strand, Bellville, Port Elizabeth (St. George's Park), Potchefstroom, Sydenham.

Stylonychia mytilus, found at Heathfield, Stellenbosch, Cedara (black vlei).

Euplotes harpa, found at Somerset Strand, Umgeni, Sydenham, Mayville.

Euplotes patella, found at Umgeni, Cedara (black vlei).
Vorticella campanula, found at St. James, Umgeni, Mayville.

(*B*) Results of Examinations of Waterlogged Soils.

Examinations of waterlogged soils were not possible until the onset of the rainy season (November) in the Transvaal, and hence the samples are few, but these have been added to the paper for the sake of completeness. All the waterlogged soils were feebly acid in reaction.

Five samples of waterlogged soil were investigated by direct examination in order to ascertain whether trophic Protozoa occurred therein. In each case the sample of soil was placed in a beaker and allowed to stand for about an hour under a bell jar. The liquid that oozed from the soil was withdrawn in a sterile pipette and examined.

Specimen 1.—Johannesburg garden soil was taken from a shallow ditch that carried off storm water and waste water from two dripping taps. It was said to be always waterlogged. A specimen was collected on 1st December, 1921, when about an inch of storm water was above its surface.

The following trophic Protozoa were counted in one-tenth c.c. of ooze:—

Rhizopoda.—2 *Amoeba radiosa*.

Mastigophora.—14 *Euglena viridis*, 20 *Oikomonas termo*, 15 *Bodo* (*Prowazekia*) *parva*, some of which contained ingested bacteria.

Infusoria.—1 *Colpidium striatum*, 3 *Holophrya ovum*.

Specimen 2.—This soil was collected in Johannesburg from the side of a land drain similar to the preceding one, but though the soil was very damp, there was no standing water. The specimen was obtained on 12th December, and one-tenth c.c. of the ooze contained the following organisms:—

Rhizopoda.—1 *Amoeba radiosa*.
Mastigophora.—13 *Euglena viridis*, 22 *Oikomonas termo*, 15 *Bodo* (*Prowazekia*) *parva*.
Infusoria.—3 *Holophrya ovum*.

Specimen 3.—This specimen was collected on 13th December, from the waterlogged bank of a shallow ditch draining the vegetable garden of the Fort, Johannesburg. Heavy rain had fallen two days previously. The following Protozoa were obtained in one-fifth c.c. of ooze:—

Rhizopoda.—1 *Amoeba proteus*, 1 *Amoeba radiosa*.
Mastigophora.—5 *Euglena viridis*, 2 *Bodo parva*.
Infusoria.—2 *Holophrya ovum*, 12 *Coleps hirtus*, 8 *Cyclidium glaucoma*, 2 *Vorticella campanula*.

Specimen 4 was a sample of waterlogged soil from the banks of the Sans Souci Dam, between three and four miles from Johan-

nesburg. It was was collected on 14th December. The following protozoal organisms were found in one-fifth c.c. of ooze:—

Rhizopoda.—2 *Amoeba radiosa.*

Mastigophora.—14 *Bodo parva.*

Infusoria.—1 *Coleps hirtus*, 3 *Cyclidium glaucoma*, 5 *Vorticella campanula.*

Specimen 5.—This was collected from flooded mealie land near Johannesburg on 2nd December. On direct examination of ooze only motile *Euglena viridis* were found, but *Bodo parva*, *Oikomonas termo* and *Paramoecium aurelia*, as well as *Euglena viridis*, were subsequently obtained in cultures, which also contained some active Vibrios.

Water cultures of each of the five waterlogged soils usually yielded the same organisms observed on direct examination, and in addition *Oikomonas termo* and *Bodo parva* appeared when previously not present in the trophic form.

From the foregoing it appears that trophic Protozoa are present normally in waterlogged soils, where cysts have also been observed, while in soils with the ordinary water content (frequently only hygroscopic moisture) the Protozoa seem to exist chiefly in the encysted condition, trophic forms only being detected in water cultures.

Appearance and Periodicity of the Protozoal Organisms Observed in South African Soils.

From the examinations mentioned before it is seen that all the soils examined so far in South Africa have contained Protozoa, the majority often occurring naturally in the encysted condition. Some organisms, such as Paramoecium, Cyclidium, were common to several of the soils, while other soils showed quite different genera, but the relative abundance of any one organism in the different soils showed considerable variation.

Occasionally, sudden crops of Protozoa appear, which disappear as suddenly. For example, a culture of soil collected at St. James was made on 31st March, 1921. *Actinophrys sol* appeared 43 days after the culture was made (that is, on 13th May). They were abundant for fourteen days, during which time apparent conjugation was observed. After this they continued to flourish for six days, and then began decreasing in number. They disappeared (possibly encysted) on 16th June, that is, 34 days after their first appearance, to reappear in very small numbers one week later. Since then they have not been observed in the culture.

Mastigophora were usually the earliest Protozoa to appear in any number in cultures. Sometimes trophic *Oikomonas termo* and *Euglena viridis* have been observed in as short a period as three hours after culture, though none could be detected except as cysts in direct examinations prior to culture. Usually motile Flagellates have appeared in soil cultures, other than as isolated units, after about two days. Certain Mastigophora have developed in cultures long before others. Thus, *Oikomonas* (*Monas*) *termo* was observed after three hours' culture, *Euglena viridis* was detected after

twenty-four hours, *Pleuromonas jaculans* was seen once only in a six hours' culture, while in water cultures of five other soils it did not appear until after twenty-seven days had elapsed.

Ciliate Infusoria appeared in cultures either concurrently with or usually rather later than Mastigophora. The shortest period of culture before motile Ciliates were detected was nineteen hours, the Ciliates being *Spirostomum ambiguum* and *Colpidium steinii*. As in the case of Mastigophora, the period for excystation showed much variation. Thus *Lacrymaria olor* appeared in a series of cultures of different soils in thirty-one hours, forty-seven hours, eight days, nine days and thirteen days respectively. In the latter cases several generations may have occurred before they were noticed.

Occasionally one specimen of a Ciliate would be observed after a short period of culture, and then no further specimen would be seen for several days. Thus *Coleps hirtus* first appeared in a certain culture after three days, as did *Lacrymaria olor* in another. Both organisms were not seen again for over a fortnight. Again, *Cyclidium glaucoma* was observed in one culture twenty-four hours after it was made. The organism disappeared from the culture and was not seen again for thirty-one days, when it reappeared in fair numbers.

In connection with the Sarcodina, it has been unusual in the cultures of soils hitherto examined to find trophic forms early in the cultures, though occasionally this has occurred. Usually Amoebae and Thecamoebae were the last groups of organisms to appear, though much variation was shown in this respect in different soil cultures. Thus, in soils from Potchefstroom and Cedara *Amoeba limax* was found in a two days' old culture, it occurred in a three days' old culture of Cedara cultivated soil, but was not observed until nine days in a culture of Heathfield soil, twenty-four days in Stellenbosch soil, and twenty-six days in soils from St. James and Simonstown. In some cultures as long as three months have elapsed before an amoeba was detected.

It is clear that dogmatic statements cannot be made, as soils vary much among themselves. We are glad to note that similar ideas regarding variability of factors have already been put forward by Martin and Lewin.

When first we attempted a determination of the number of species of Protozoa found, which was done after twenty-three soils had been examined, we considered that the Ciliates were the most numerous, Flagellates next and Sarcodina least, which observation corroborates that of Fellers and Allison. After examining a few more soils, making twenty-seven in all, it was found that eighteen species of Ciliates, ten of Flagellates, and twelve of Sarcodina had been found and identified. The relative positions of Flagellates and Sarcodina as regards number of species thus were interchanged.

The relative numbers of individuals of each of these groups varies, and from the point of view of actual total numbers, Flagellates are preponderant.

With regard to viability, Ciliates last longer in a culture than any other class of Protozoa. For example, *Paramoecium aurelia* appeared in a culture and was still present in abundance 190 days after, other Protozoa having disappeared.

We know from direct observations that daily variation in numbers of any one organism occurs in a given quantity of soil culture. Counts were made of the numbers of *Actinophrys sol* and *Paramoecium aurelia* found in 1 c.c. of certain cultures of soil. The daily counts for *Actinophrys sol* over a short period were 1, 15, 19, 40, 4, 13, 12, 7, 20. In the case of *Paramoecium aurelia* the daily counts were 48, 34, 31, 32, 38, 29, 15, 7, 10, 13. Cutler and Crump (1920) have shown daily variation in the number of active Flagellates in soil cultures from Broadbalk, Rothamsted, England.

Environmental Effects.

Some observations were made to endeavour to determine the effects of variation in environment on the Protozoa in the soil.

Influence of Temperature.

Cultures of soil maintained at 37°C. and 45°C. compared with those kept at room temperature (about 15°C. to 20°C.) showed that room temperature enabled Protozoa to flourish better.

Influence of Light.

A series of observations were made to determine whether darkness had a retarding or accelerating effect on the development of Protozoa in soil cultures. It was found that there was little difference in the results obtained with cultures of soil kept in the dark and those kept in the light, but in the case of a culture of Mayville soil Protozoa appeared rather earlier as motile forms when the culture was kept in the dark (six days as contrasted with nine days).

Influence of Types of Soil.

In regard to numbers of Protozoa associated with different types of soil, dark relatively heavy loam, such as is found at Sydenham, Cedara (black vlei soil), and Onderstepoort showed good results, while sandy soils such as those collected at Kimberley, Rosebank (Cape), and Johannesburg (Houghton Estate) were the least productive in respect to Protozoa. This appears to corroborate the results obtained by Waksman, that the amount of organic matter is a limiting factor to Protozoa.

As a rule, the number of Protozoa obtained in cultures was greater when the sample was taken near the surface of the soil, and the number of Protozoa decreased with the depth at which the sample was taken. We are investigating the matter further.

Influence of the Season of the Year.

The season of the year appears to have some influence, at any rate, in some cases. Thus, as far as the present observations

permit, soils from the Transvaal and Natal collected towards the end of the summer (for example, at the end of March, in April, and early May) yielded more kinds of Protozoa than did soils collected in the drier winter months, such as July.

Influence of Pulverisation of Soil.

Some experiments were undertaken to determine the method of attachment of protozoal cysts to the soil and the effect of soil pulverisation. In direct examination of soil, detection of cysts was not easy. The effect of fine pulverisation or trituration of soil in water was to increase the number of cysts discernible by separating them from the soil partices to which they were firmly adherent. Two examples may be cited:—

(*i*) A definite quantity, 0·1 gram, of Grahamstown soil was weighed and put in a watchglass with 2 c.c. of water on top of it. The fluid and top layer of soil were examined after ten minutes. The total number of protozoal cysts detected was 7.

The fluid and soil were then rubbed together with a small glass pestle for two and a half minutes, allowed to stand for ten minutes, and then the fluid and surface layer of soil were again examined. The number of cysts was 11. The material was again returned to the watchglass and the fluid and soil were rubbed together for a further two and a half minutes, allowed to stand for ten minutes, and then re-examined. The number of cysts detected was 17.

(*ii*) In another experiment, 0·1 gram of cultivated dolerite soil from Cedara was put in a small glass tube, 2 c.c. of water was poured on the top, and it was allowed to stand for thirty minutes. The cysts in the liquid and surface layer of soil were counted, the number being 7.

The soil and liquid were returned to the tube, the soil was well rubbed up for two and a half minutes, a turbid brownish fluid being obtained after standing for fifteen minutes. This fluid and the surface layer of soil were examined, and 16 cysts found. The procedure was repeated as before, and a further examination resulted in 18 cysts being detected.

Thus, the more finely the soil was pulverised the more readily the cysts became detached from the soil particles and the larger was the number of cysts detected.

Two cultures were made of equal quantities of the cultivated dolerite soil from Cedara. In one culture soil as dug was used, in the second finely pulverised soil. It was found that trophic Protozoa (such as Ciliates and Flagellates) appeared more quickly in the culture of the finely pulverised soil than in the soil as dug, the periods being one day and three days respectively.

It is probable that the colloidal complex of organic and inorganic compounds more or less saturated with water that surrounds the particles of soil, together with the surface tension of the films, is the cause of the very close adhesion of the Protozoa, either trophic or encysted, to the soil particles. It also affords an explanation of the difficulty of detecting trophic Pro-

tozoa in soil by direct examination. In the case of soils in South Africa, it seems from the above-mentioned experiments that the use of finely-divided soils will reveal more Protozoa than when the soil is examined without previous pulverisation.

Finely tilled soils are stated generally to yield heavier crops than those less well cultivated. It is possible that the finer pulverisation of the soil may release more protozoal cysts, which, in the presence of the moisture necessary for their development as trophic forms, will produce Protozoa that may react on organisms inimical either directly or indirectly to plant growth. There may thus be a protozoal factor in the production of heavier crops after fine tillage.

A minimum moisture content in the soil seems necessary for the growth of Protozoa therein.

It was found that when a genus of Protozoa such as Amoeba Actinophrys, Paramoecium, Euglena or Cyclidium appeared in one culture in the trophic condition, several other cultures from *different* localities contained the same organisms simultaneously. This seems to indicate that these Protozoa in water culture react to some external stimulus, as yet not fully determined, and assume the trophic condition.

General Remarks.

The following general remarks may, for convenience, be collected and set forth here.

On the whole, relatively few bacteria have yet been encountered, though in some cases bacteria were seen ingested by Amoebae, Mastigamoeba, Bodo and Colpoda. This may be due to the fact that the nitrogen content of most South African soils is relatively somewhat high, so that the environment for bacteria may not be quite so favourable as in other parts. Dryness may also be a factor.

The nitrogen content of South African soils is a difficult subject to a protozoologist. According to Mr. A. Stead (1920) of the Grootfontein School of Agriculture, "the nitrogen factor would not appear to be deficient in our average soil; on the other hand it is doubtless often excessive." Again, "the average soil of the Union would seem to be more deficient in phosphatic food than in any other." The relatively large amount of sunshine causes partial sterilisation of the soil and prevents denitrifying bacteria from thriving. The relative lack of rains implies that the nitrates are not much lost by washing away (leaching). An important factor of the soil in South Africa for plant food is the balance between nitrogen and phosphates.

According to Waksman (working in the United States of America) soil Protozoa do not have any appreciable influence upon ammonification by bacteria. As far as the present evidence goes, Waksman's (1916) remark also seems to apply to South Africa.

The natural medium for moistening soil is water, more especially rain water, and so water cultures of soil should reveal a content

of Protozoa and Bacteria approximating to the normal or natural. Certain other workers appear to have laid too much stress on artificial culture-media, which unduly favour bacteria, and probably produce an artificial pabulum for Protozoa on which they have to subsist or else die out. In artificial media it is probable that the numerical proportions of Protozoa and Bacteria are altered, as also are their biological activities. Hence some of the inferences made by certain workers in other parts of the world, using bacteriological media, may need emendation for South African conditions.

From the few observations made up to the present it seems that relatively tenacious loam soils contain the greatest numbers of Protozoa and that sandy soils contain fewest organisms. Cultures of acid soils have in some cases contained more genera than alkaline or neutral soils, the acidity or otherwise of the samples of soil being determined by litmus compression tests. It seems probable that the colloids of the soil may play an important part in the regulation of the activities of the protozoal fauna. Partial sterilisation of the soil in South Africa by solar radiation is also a limiting factor, and any form of partial sterilisation limits Protozoa according to Waksman.

In addition to Protozoa, certain Metazoa have been observed by us in cultures of South African soils. Rotifers, *Chaetonotus maximus* (belonging to the Gastrotricha), Nematodes and Oligochaetes have been found. This is in contrast to the finding in New Jersey soils, where Nematodes were the only Metazoa observed.

In water cultures of almost all the South African soils examined diatoms were found, and these may serve as food for some of the Protozoa present. It is known that in some cases the soil samples were obtained from areas known to be flooded at certain times of the year, or to be subjected to irrigation.

It will be noted that many of the Protozoa found in cultures of soil are of similar genera and species to those found in natural fresh waters, but the relative numbers and proportions of the different organisms observed in soil cultures are different from those of normal aquatic protozoal faunas.

Summary.

A summary of a paper such as the present one is difficult, both on account of the nature of the subject, with its many and varying factors, and the stage of the work. Some of the principal results are as follows:—

(1) Examination by direct observation and by water culture of a number of South African soils from the Cape Province, the Transvaal and Natal, under conditions of cultivation varying from virgin soil to heavily cultivated sugar land, has shown the presence of genera of Protozoa belonging to the Sarcodina, Mastigophora and Ciliata. The genera and species vary considerably, both with the locality and with the degree of cultivation of the soil.

(2) Few trophic Protozoa were detected in fresh non-waterlogged soils, the organisms occurring mostly in the encysted or resistant condition.

(3) Up to the present the largest number of species of Protozoa from any one soil was twenty-two, obtained from good vineyard soil under cultivation at Stellenbosch; the smallest number was one, obtained in cultures of soil from under a mango tree in the Durban Botanic Gardens. The geographical distribution of the Protozoa found in South African soils is given.

(4) Examination of waterlogged soils has shown the presence of trophic Protozoa. The fauna was relatively abundant compared with that of non-waterlogged soils and contained some different genera. Excess of moisture probably causes excystation.

(5) The relative abundance of any one kind of Protozoön in different soils shows considerable variation. The sequence of appearance of the different groups of Protozoa in water culture is usually Mastigophora, Ciliata and Sarcodina. Ciliata were the most numerous as regards species, Mastigophora and Sarcodina being about the same in number of species. From the point of view of actual numbers of organisms Flagellates are the most numerous. In regard to viability, Ciliates persist longer in a culture than any other class of Protozoa.

(6) Environmental effects were noted. Room temperature (15°C to 20°C) produced better growths of Protozoa in cultures than did higher temperatures. Darkness seemed to make little difference in the rate of development in cultures. Dark, heavy soils containing much humus yielded more kinds of Protozoa than sandy ones, the amount of organic matter apparently being a limiting factor to Protozoa. Samples of soil taken near the surface usually yielded more Protozoa than deep ones. Transvaal and Natal soils collected towards the end of the summer (rainy season) yielded more kinds of Protozoa than those collected in winter. Cultivated soils tended to yield more species of Protozoa than uncultivated soils.

(7) Cysts of Protozoa are very closely attached to the soil particles. It was experimentally determined that the more finely the soil was pulverised the more protozoal cysts could be detected. As finely tilled soils usually yield heavier crops than less well cultivated ones, it is possible that the finer tillage detaches protozoal cysts, which, if sufficient moisture is present, will develop into trophic forms that may exert either a direct or indirect action on organisms inimical to plant growth.

(8) So far as our investigations go, relatively few Bacteria appear to occur in the soils of South Africa, probably due to the dryness and large amount of sunshine causing partial sterilisation. Up to the present the ingestion of Bacteria by Amoebae, Flagellates and Ciliates has only been observed on a few occasions.

Acknowledgments.

Our thanks are due to many kind friends for samples of soil for examination, especially to Mr. A. Stead, of Grootfontein School of Agriculture, to Messrs Parish and Williams, of Cedara, and to Mr. T. Hall, of Potchefstroom.

We also wish to thank the Research Grant Board, for a grant towards the expenses incurred in these investigations.

References to Literature.

Bütschli, O. (1880-89). "Protozoa," Bd. I., Abt. 1-3, in Bronn's "Tier-reichs."

Cutler, D. W. (1919). "Observations on Soil Protozoa." *Journ. Agric. Sci.*, IX, pp. 430-444. See also *Annals Applied Biology*, VII, pp. 11-24.

Fellers, C. R., and Allison, F. E. (1920). "The Protozoan Fauna of the Soils of New Jersey," *Soil Science*, IX, pp. 1-26.

Goodey, T. (1916). "Further Observations on Protozoa in Relation to Soil Bacteria." *Proc. Roy. Soc.*, B, LXXXIX, pp. 297-314.

Kent, W. Saville. (1880-82). "A Manual of the Infusoria." 3 vols.

Kopeloff, N., and Coleman, D. A (1917). "A Review of Investigations in Soil Protozoa and Soil Sterilization," *Soil Science*, III, pp. 197-269. (Useful Bibliography.)

Martin, C. H. and Lewin, K. R. (1915). "Notes on Some Methods for the Examination of Soil Protozoa," *Journ. Agric. Sci.*, VII, pp. 106-119.

Russell, E. J. (1921). "Soil Conditions and Plant Growth," London. 406 pages. (See especially pp. 288-294 and Bibliography.)

Stead, A. (1920). "The Agriculture and Soils of the Cape Province (Witkop-Burghersdorp)." *Union of South Africa, Dept. of Agric. Reprint*, No. 40, Pretoria, 48 pages.

Waksman, S. A. (1916). "Studies on Soil Protozoa," *Soil Science*, I, pp. 135-152. See also Ibid., II, pp. 363-376.

WILD BIRDS AND BILHARZIASIS.

BY

F. W. FitzSimons,

Director, Port Elizabeth Museum.

Read July 11, 1921.

In the past much has been written in reference to water-frequenting birds being responsible for carrying the ova of fishes in mud adhering to their feet. This was accepted as the solution of the incidence of certain species of fish being found in pools and ponds where the water dried up in times of drought. It is now known that these fishes have evolved special powers of survival by burying themselves in mud, and lying dormant. It has been shown, also, that the eel can travel overland from pool to pool.

The hypothesis which has now been advanced, that birds carry young snails on mud adhering to their toes, is a plausible one; but like many hypotheses, when thoroughly investigated, it has been found to be erroneous. For twenty-five years I have made a careful study of South African ornithology, especially its economic side, both in the field and in the laboratory. At various

times, especially during the summer season, I made examinations of the feet of water-frequenting birds, and in the majority of instances there was no mud on their feet; whilst others had only a film of mud. In a small number of cases the feet had small quantities of mud adhering to them. The ducks and various wading birds are invariably in the water, and when rising the mud is washed from the feet. The birds were shot on the wing immediately after leaving the water. Following this up, I made the most careful examinations of mud scraped from the feet of water-frequenting birds, and never succeeded in discovering young snails or the ova of snails in this mud.

I have further evidence to offer of the innocence of birds in the spreading of fresh-water snails. In the vicinity of Port Elizabeth we have a stream known as Baakens River, which has been infested with bilharziasis for at least half a century. This stream swarms with fresh-water snails. Twenty-five miles from Port Elizabeth by road there is a perennial stream known as Van Staadens River. A distance of about ten miles separates the upper reaches of this river from the former, while a bird flying in a straight line from the lower reaches of Baakens River would only cover a distance of fifteen miles at most. During three successive years I visited Van Staadens River during the middle of summer when snails were active and easily procurable. On each occasion I spent three weeks observing the bird life and searching for snails. I failed to discover a single snail in a stretch of river covering two miles. During the same time of year Baakens River was swarming with snails. It is obvious that the water-frequenting birds would constantly migrate from the one river to the other. Why then is Baakens River swarming with snails, when according to the new hypothesis birds are carriers of the eggs and young of snails from river to river?

To further strengthen my case in favour of the protection of all water-frequenting birds, I made a systematic examination of Baakens River for ten miles along its course. The river runs through the city half a mile before discharging its water into the sea. Indians living near the stream keep ducks and geese. I dredged with nets along the portion frequented by these birds, at intervals covering several years, and after two hours' strenuous work some half-dozen snails would be the result. On the contrary, from beyond this locality for a mile up the river the water is swarming with snails during the summer season. There are no ducks in this portion of the river. Proceeding up stream beyond the city's boundaries, the snails were not nearly so abundant. In some of the upper reaches of the stream in secluded places where human bird slayers seldom penetrate, it was with difficulty I found snails. The conclusions to be drawn from this work are:—

(1) The ducks and geese devour the snails in the portion of the river frequented by them.

(2) In the stretch of river near the city which is swarming with snails, wild birds are rarely seen, owing to the proximity of men and the persecution to which the birds are subjected.

(3) The comparative scarcity of snails in the secluded portion of the river is owing to the greater prevalence of wild birds in those portions of the river.

Granted for the sake of argument that wild birds occasionally carry a few snail ova from pool to pool on their feet, this is nothing in comparison to the vast numbers of snails they devour. It must not be forgotten that every snail devoured by birds is the potential parent of a small colony of snails.

After twenty-five years' close observation, research and experiment, I most emphatically assert that birds are not responsible for the spreading of fresh-water snails; that, on the contrary, they are Nature's chief enemies of snails; and in the degree that they are persecuted, just in that degree will snails increase in numbers and infest the rivers of South Africa.

Apart from the evidence I have advanced in favour of birds checking the multiplication of the snail, it has been demonstrated in Baakens River by me, and elsewhere by Dr. Cawston and by Dr. Porter, that tame ducks eliminate the snail. I claim that my investigations prove that wild water birds do not spread the snail pest by carrying the ova and young on their feet. This being so, it is obvious that if tame ducks clear a pond of snails, wild ducks and other snail-eating birds will do likewise if allowed to multiply. Floods are, without question, the chief cause of the spread of fresh-water snails, and wild water birds, fish, crabs and frogs are Nature's checks.

The small fresh-water fish common in the Baakens River and known locally as the "Kurper," and to science as *Spirobranchus capensis*, feeds voraciously on young snails. This fish is infinitely superior to "Millions" owing to its hardiness and capacity for thriving under conditions fatal to the great majority of other fish, including "Millions."

Having suffered for several years with bilharziasis in Natal when a boy, I naturally have taken a lively interest in all that bears on the disease, and in consequence of this special interest my investigations were of as thorough a nature as I was capable of making them.

List of Birds which Prey on Fresh-Water Snails.

White Stork; Springhaans vogel; Great Locust Bird (*Ciconia alba*).
Black Stork (*Ciconia nigra*).
Marabou (*Leptoptilus crumeniferus*).
Wood Ibis (*Pseudotantalus ibis*).
Hammerkop; Paddevanger; Mudlark (*Scopus umbretta*).
Greater Flamingo (*Phoenicopterus roseus*).
Lesser Flamingo (*P minor*).
All species of Geese and Ducks.
All species of Rails, Crakes, Moorhens and Reed Hens.
Red-knobbed Coot (*Fulica cristata*).
Peter's Fin-foot (*Podica petersi*).
All species of Red Shanks, Green Shanks and Sandpipers.
All species of Ruffs, Knots, Stints and Snipe.

None of these birds does any harm to the agriculturalist, stock farmer, or fruit farmer, consequently it is nothing less than a crime to take the lives of such valuable feathered allies, which wage incessant war on snails and a host of other pests.

THE EXPERIMENTAL INFESTATION OF FRESH-WATER SNAILS, WITH SPECIAL REFERENCE TO THE BILHARZIA PARASITE.

BY

F. G. CAWSTON, M.D. CANTAB.

Read July 11, 1921.

One of the most interesting parts of the study of the life-history of the Bilharzia and allied parasites is that which deals with the survival of the parasites in their various stages.

There is no doubt that those Bilharzia worms which have reached maturity in the liver can live in the blood-system of a human being for from ten to twenty years, and are sometimes found alive after the death of their host; Fasciola parasites more often cause wasting and death of the infested oxen and sheep.

The eggs which escape from the system of a bilharzia patient may remain unhatched for several days, but die as soon as they become dry. I have kept them alive in urine for several days, but they hatch as soon as they reach fresh water on a warm day.

The miracidia which escape from these eggs are just visible to the naked eye, and can be seen swimming about for several hours but will not survive more than twenty-four hours and are harmless to human beings, as they cannot prolong their existence outside a suitable fresh water snail.

In 1915 and 1916 I carried out some experiments at Maritzburg with the object of experimentally infecting *Physopsis africana* and *Limnaea natalensis,* using snails I had collected from the Umsindusi.

In December, 1917, I repeated these experiments at Potchefstroom, using *Isidora schackoi* Jickeli from the golf links. This snail sometimes harbours a schistosome, *C. gladii.* Thirty-eight young Isidora were selected and placed in water swarming with miracidia. None were examined for sixteen days, by which time bilharzia infestation should have been clearly marked, but all were dissected before the twenty-eighth day. Thirty-one were free from cercariae, while the remaining seven showed signs of early infestation with *Cercaria frondosa*, an amphistome which infested practically all the mature Isidorae in the pool from which these snails were collected.

On May 14th some water containing numerous schistosomes from *Physopsis africana* from Mrs. Oldham's pool in Sydenham

were placed by themselves in a test-tube of water. Twenty-six hours later many were seen still actively swimming about in the water. The prongs of this cercaria, which is probably *C. gladii*, are equal in length to that of the tail. The snails were obtained from a pool frequented by cattle and birds. However, if stored for two days apart from fresh-water snails, water becomes free from bilharzia infection.

Though drying kills this kind of fresh-water snail, others, such as *Tiara tuberculata*, which is heavily infested with cercariae at the Natal Coast, can resist drought for several weeks at a time and, when the rainy season returns, continue to emit numerous cercariae without being exposed to fresh infection.

As I was desirous of obtaining some adult bilharzia worms from parasites which I had obtained from fresh-water snails which I had myself experimentally infected, I repeated these experiments in February, 1921, using some *Physopsis africana* and *Limnaea natalensis* which I had grown from eggs in water kept free from other sources of infection. These snails were placed in a jar of water containing miracidia which I obtained from the urine of a patient who had contracted bilharzia disease through bathing in the pools at Sarnia, and thirty-three days later, on March 21st, mature bilharzia cercariae were found in one Physopsis. One Limnaea which was dead showed no cercariae. The Physopsis was only 10 mm. in length.

On March 23rd, thirty-five days after these snails were exposed to the miracidia, a free-swimming cercaria was clearly visible to the naked eye and readily identified by a hand-lens, swimming about in the water. No cercariae or other signs of infection were seen in four Limnaeae, one of which was dead before dissection, but numerous mature bilharzia cercariae were found in the only remaining Physopsis, which was only 9 mm. in length and was the smallest infested specimen I had seen. The cercaria varied in size according to its movements, but both head and tail were about 0.175 mm. in length, and the prongs of the divided tail were about a quarter the length of the tail. The cercariae were injected into five guinea pigs in order to secure their adult forms, but the results were negative at the end of three months.

Seven *Limnaea natalensis* were placed in a jar of water containing numerous miracidia on March 9th and kept until May 17th, when dissection failed to reveal the presence of cercariae, and the liver substance appeared to be normal. This jar of water also contained a few Physopses which were dead when the Limnaeae were examined.

On March 31st four *Limnaea natalensis* from 11 mm. to 14 mm. in length, which had been kept in water with the ova of Fasciola since February 14th and 18th, showed no evidence of sporocyst or redia-formation.

The pools at Sydenham and Mayville contain several cercariae which closely resemble *S. haematobium*, but are not identical with it. Some of these have developed into *S. bovis* in my experimental animals, and although I do not think that *S. bovis*

has been recorded in man, I have seen in a patient ova 0.236 mm. in length and 0.06 mm. in breadth, which is much longer and relatively narrower than the ova of *S. haematobium*. These ova closely resemble those I obtained from the adult female *S. bovis*. The cercariae are possibly *C. gladii*, which is redia-produced. Other cercariae in these pools are *S. mansoni*, and I have obtained its lateral-spined ova from a patient who contracted the infection from the Mayville pools last year. It is possible that the survival-time of these schistosomes during their free aquatic existence varies with the different species

The survival time of the free-swimming bilharzia cercaria in South Africa is a short one, partly because it cannot encyst and partly because its snail-host is not provided with an operculum to resist drought. Whilst active in fresh water, and said to become more active in water containing minute traces of salt, I have observed that the bilharzia cercariae are readily destroyed by strong solutions of salt. This point is of great importance because the intermediary hosts of various trematode worms, particularly the liver-fluke parasite, are continually being washed down-stream into the lagoons along the Natal Coast, and I have recently obtained several varieties of them at the mouth of the Umbogintwini and have found *Limnaea natalensis* attached to floating wood where the river breaks through the sand-bank to empty into the sea. When the water in these lagoons is fresh, as it commonly is at low tide and during the floods, the cercariae which escape into the lagoon water are likely to prove a danger to swimmers; but, when the tide is coming in and the water in the lagoon is mixed with sea water, the free-swimming cercariae are rapidly killed and the lagoon is rendered fit for bathing. Fortunately from a public health point of view the current is often too strong when the tide is receding, and visitors to these popular seaside resorts are advised to bathe in the lagoons only when the tide is coming in. The risk from disease from cercariae when carried up the river is considered to be of less importance than the risk of death from sharks when carried out into the open sea.

The survival time of the miracidium which escapes from the bilharzia egg is only a few hours, but should it reach *Physopsis africana*, mature cercariae will escape in thirty-five days. These cercariae last as free-swimming organisms only a few hours; but, if they effect an entry into a suitable host, in three months they develop into mature parasitic worms capable of laying eggs. The complete cycle is therefore about four months. This is of importance, as it indicates how the disease is introduced into new countries.

If a pool infested with *Physopsis africana*, but free from bilharzia infection becomes contaminated with the excreta of a bilharzia patient, the water will swarm with bilharzia cercariae capable of attacking man within five weeks, and three to four months later one may expect an outbreak of the symptoms of bilharzia infection amongst those who have bathed or drunk this water.

Whilst on active service I warned the Defence Department of the existence of suitable hosts for the Egyptian form of bilharzia disease in the Durban suburbs, where troops from Egypt were continually arriving. In 1919-1920 I posted to Dr. E. C. Faust *Physopsis africana* from these pools infested with the Egyptian parasite, *Schistosoma mansoni*. Dr. Annie Porter found both *Physopsis* and *Planorbis pfeifferi* in these pools infested with it. In June of this year I came across the first case of Egyptian schistosomiasis in a boy of twelve who had contracted this intractable disease along with infection with *Schistosoma haematobium* through bathing in the pools at Mayville and Sydenham in 1920.

The disease is therefore endemic in South Africa, and has probably been introduced by troops returning from Egypt. Fortunately I have been able to show that the parasite in Natal can be destroyed by ipecacuanha as readily as it has been proved to be in Egypt.

A STUDY OF THE LIFE-HISTORY AND METHODS OF CONTROL OF THE ROOT GALL NEMATODE, *HETERODERA RADICICOLA* (GREEF MULLER), IN SOUTH AFRICA.

BY

J. Sandground, M.Sc.

Lecturer in Zoology, University of the Witwatersrand, Johannesburg.

With Plates VI, VII, VIII.

Read July 13, 1921.

Introduction.

The nematode, *Heterodera radicicola*, described in this paper, is a parasite of many plants of economic importance. While much work has been done in other countries, more especially in connection with control measures, a number of interesting points in connection with the life-history of the worm needed elucidation. The present paper is an attempt to describe *Heterodera radicicola* as it occurs in South Africa, and to make the account as complete as possible so that the parasite may be compared and contrasted with *H. schachtii*, the sugar beet nematode of Europe, and *H. radicicola*, as described by workers in Europe and elsewhere. *H. radicicola* causes swellings or galls on roots which are sometimes termed "eelworm" disease.

Material and Methods.

The material for my first observations on the parasite consisted of tomato plants growing in the experiment grounds of the Division of Entomology at Rosebank, Cape Peninsula. Infected

potatoes proved to be the most convenient material for studying the life-history of the nematode, since they can be easily scraped or cut and harbour the worm for a considerable time in all stages of its development. To a great extent the present observations were based on material consisting of infected potatoes from parts of Natal, the Transvaal and Basutoland.

Seedlings of tomatoes, potatoes, peas and beans have been used for most of the experiments with the nematode.

A large number of cultivated and wild plants have been examined, and a list of plants found to be infected in Nature has been made (see page 412). It is probable that such wild plants serve as reservoirs for the nematode, whence it spreads to new cultivated hosts.

Cultures of the larvae of *Heterodera radicicola* were made in wet sand and in water, but it was found that the development of the larvae was arrested and that no further development occurred unless the worms were able to enter the roots of a new host plant.

The adult females of *Heterodera* are usually visible as small, pearly white, glistening bodies, about the size of a pin's head. They are chiefly situated in small cavities in the peripheral portion of the infested root, and are most conveniently removed by teasing the surrounding root tissues under water and lifting the worms with a pipette. For isolating the smaller intermediate stages of the worm the use of a binocular microscope is advantageous.

Owing to the transparent nature of the cuticle it was found possible to determine most of the detailed anatomy of the *Heterodera* without staining. Much time was given to the study of living material. Permanent preparations were not very satisfactory owing to the impermeability of the cuticle to most fixatives and stains. The fixatives found most useful were hot 70 per cent. alcohol, Carnoy's fluid and Bouin-Duboscq fixative. For staining it was found that a fairly weak solution of acetic-acid-carmine acting overnight gave better results than haematoxylin, methylene blue and other stains. For mounting specimens permanently, a five per cent. solution of carbolic acid in alcohol was found very convenient. This mounting medium also helped to clear specimens and could be easily ringed with enamel.

It may be mentioned that the size of root galls cannot always be regarded as a reliable indication of the extent of infestation by the parasite, as this may vary with different hosts.

The Life-History of *Heterodera radicicola*.

The life-history of *Heterodera radicicola* as found in South African plants may now be considered in some detail.

The Eggs (Plate VI, Figs. 1-11).—The eggs are mostly easily obtained in numbers by opening the gravid female worm. They are usually found still within the oviduct in the unsegmented condition, but occasionally the segmentation is quite far advanced.

Sometimes the slow-moving larva, having emerged from the egg covering, is found to have penetrated the wall of the oviduct, and is moving about freely in the general body cavity.

The eggs are ellipsoidal bodies, usually symmetrical, but when viewed from the side may appear slightly kidney-shaped. Their size varies considerably even when taken from the same parent. The average length of a batch of over one hundred eggs taken from infested potatoes from Natal was found to be 92.4μ, and the breadth 34.6μ. The length varied between the extremes of 82.5μ and 115μ, and the breadth between 33μ and 36μ.

Eggs taken from potatoes from Potchefstroom: The average size was 79μ long by 30μ broad, with a variation of length between 70μ and 85μ, and of breadth between 24μ and 35μ.

On one occasion exceptionally large eggs were taken from a female worm in the roots of the Snapdragon (*Antirrhinum*), one individual measuring 119μ in length and 43μ in breadth. This great variation in size bears no relation to the stage of segmentation attained by the egg at the time of measurement, as might at first be imagined. Abnormally shaped eggs are occasionally found; these, as a rule, being malformed in the uterus.

The eggs are enclosed in a chitinous transparent covering. Their contents are granular but small globules, apparently fatty in nature, predominate. The nucleus can, as a rule, be easily recognised as a relatively clear spot, centrally situated. Segmentation proceeds regularly and almost equally. Polar bodies, two in number, were observed. The morula stage is formed by about thirty blastomeres, after which the gastrula stage is produced by invagination or embole. After gastrulation, further multiplication and segregation of the blastomeres occurs, until eventually a vermiform embryo coiled into two or three loops within the egg covering is formed. (Fig. 2.) A slow movement soon commences within the egg, the embryo exerting much pressure upon the egg covering. Although the "spear" in the buccal cavity is already fully developed, the embryo does not utilise it to pierce its way out, but an escape is eventually effected by the egg "shell" rupturing at one end, and so liberating the larva.

The eggs are usually found to the number of about sixty in the gravid female. As a general rule they hatch while still located in the dilated uteri, and the final escape does not occur until after the parent's death. The worm consequently cannot be regarded as oviparous, and at no time have I seen evidence of egg laying; indeed this does not appear possible, because the vaginal orifice of the female ceases to become prominent soon after egg formation commences. With normal weather conditions in Johannesburg five or six days was the period necessary for the complete development of eggs isolated from the parent in a glass container.

The Free Living Larva.

The larva (Fig. 12) on escaping from the egg measures from 345μ to 370μ long, the average length being 358μ. The maximum

breadth is 15μ. No evidence was seen of the larva having undergone an ecdysis before emerging from the egg, although special attention was paid to this point.

The movement of the larva of *Heterodera* is slow and languid, a feature to be contrasted with the rapid motions made by other free-living and saprophytic nematodes such as certain Tylenchidae. The movement of the larva, even when kept in water, is scarcely such as to indicate any appreciable progress in a definite direction.

The structure of the larva (Fig. 12) is that of a typical specimen of the genus Tylenchus, and it is only a consideration of size and mode of movement that might allow one to differentiate it from larvae of Tylenchidae.

The cuticle is relatively thin and transparent, and even under the highest magnification, indications of delicate transverse striae are only occasionally visible. Dermal muscle fields could not be detected under the cuticle, as described by Bessey.

The anterior end of the larva is conical in shape, and the body, which is almost uniform in thickness throughout the greater part of its length, gradually tapers to a subacute tail.

The *lip region* at the anterior end is marked by a small protuberance which is constricted from the rest of the body by a shallow groove, and is pierced by the spear.

The *spear* is a slender-pointed organ, probably of a chitinous nature. In the larva it measures from 14μ to 16μ in length. Its breadth is approximately 1.5μ, and it tapers to a point. At its base are three small swellings, symmetrically disposed, to which the oesophagus is directly attached. The spear can be protruded for some short distance through the buccal aperture, and is used as a battering organ when the larva enters the root. It is probably pierced by a very fine canal through which liquid food may be absorbed into the oesophagus.

The *oesophagus* is a narrow, slightly coiled, tube, 40μ to 45μ in length. The lumen is lined with cuticle, and is continuous with the spear. At the posterior end of the oesophagus the lumen is dilated to form a spherical bulb with thick walls, and functions as a suction organ.

The *intestine* is the widened part of the alimentary tract behind the oesophageal bulb. It occupies practically the entire body cavity, and is filled with food globules and irregular granules of varying sizes. The intestine terminates in a very short rectum opening to the exterior by an anus on the ventral surface of the body about 50μ from its extremity.

The *excretory* and *nervous systems* are difficult to see. The excretory canal can occasionally be observed with an oil-immersion objective as a delicate sinuous duct running in the middle of the body and opening by a pore just posterior to the oesophageal bulb.

The nervous system is even more difficult to detect. Indications of a few nerve fibres encircling the oesophagus behind the bulb have been observed. Attempts to bring out further details

of the nervous system by intra-vitam staining with methylene blue and methyl green have not been successful.

Not even traces of the gonads are to be seen in the larva at this stage.

The larva may in some cases remain and continue to develop in the original root in which it was produced, but under unfavourable circumstances, such as result from the decay of the root, it makes its way into the soil. The larva in the soil is able to withstand many adverse physical conditions, such as extremes of moisture, and, to a less extent, of dryness, and of heat. It gradually utilises the food granules stored up in the intestine until that organ at length becomes quite transparent and almost devoid of granules.

When observed soon after emerging from the egg, the tail of the larva always tapers to an acute extremity. However, larvae isolated from soil, first sterilised by heating and then infected with infested roots, nearly always have an obtusely rounded tail. This indicates the probability of the larva undergoing an ecdysis in the earth. Other evidence of discarded cuticles found in the soil and of larvae with loose fragments of cuticle attached to them confirms this view.

On reaching a growing plant the larva seeks a tender portion of the young root, such as the growing point, and making use of the buccal spear, forces an entrance. It eventually makes its way into the vascular tissues of the root and commences to absorb the plant juices and to grow. The largest larvae found in infected roots measured from 500μ to 520μ in length, and 23μ in thickness.

After attaining this size the larva still continues to absorb food, with the result that the body becomes much broader and decreases correspondingly in length. The spear, oesophagus and other organs in the anterior portion of the body remain unchanged, the thickening being confined to the posterior two-thirds of the body. The larva has now reached the stage represented in Fig. 13. Its length is usually about 400μ, but variations from 360μ to 450μ not infrequently occur. The width of the body in the region of the oesophageal bulb is approximately 28μ, and the maximum thickness is about 50μ.

Up to this stage the gonad rudiments are not yet visible. The metamorphosis, which now commences and marks the further development of the parasite accompanying sexual differentiation, is complicated, and is characteristic of the genus *Heterodera*. This metamorphosis, about to be described, has been compared with the development of the Lepidopteran imago inside the chrysalis or cocoon.

The Development of the Male.

The larva having already commenced to feed and to set up a large reserve food supply, is by this time more or less permanently fixed in position in the root. Feeding gradually ceases

and a new cuticle is formed close under the old one. The separation of the cuticle soon begins, and finally the organism becomes an amorphous mass of protoplasmic granules enclosed in the original skin, with its pointed spine-like tail. The spear of the original larva is not retained and eventually disappears, a new spear being produced later. A period of apparent inactivity now ensues, the duration of which may be extended and is not easy to estimate. At any rate, it seems probable that, should conditions make it necessary, the further development of the animal can be suspended for a considerable period.

Indications of the differentiation of the sex of the parasite are occasionally manifested at this stage by the appearance of a mass of dense cells in the posterior part of the body. These cells may be interpreted as the incipient gonads, but as their fate cannot be followed in the later development, their significance cannot be emphasised. At this stage a period of cellular rearrangement occurs, and after a time the internal mass assumes a vermiform shape. Lengthening then commences, with the result that the worm becomes folded up inside its sac-like larval skin until there are as many as four complete coils. Movement on the part of the worm inside the old skin becomes evident some time before the metamorphosis is complete. Two or three days before the male worm emerges the movement increases in vigour. By this time all the organs of the mature worm are already formed and the spear is seen to be making rapid motions inside the buccal cavity in order to effect an exit. A way of escape is finally found by the rupture of the enveloping sac as a result of the pressure exerted by the worm inside. (Plate VIII, Fig. 18.)

This is the second ecdysis that has been observed so far in the evolution of the male. No evidence of further moults by the male worm whilst still enclosed in its old cuticle, such as have been stated by Stone and Smith (1898) to occur, has been obtained.

On escaping from the larval skin the length of the adult male worm may vary from 590μ to $1,200\mu$, with an average thickness of about 30μ. Further growth is rapid, the worm already commencing to make use of the plant juices in the root. The maximum size of an adult worm that I have met with during these investigations was attained by an individual isolated for nearly three weeks in watch glass with potato cuttings. The size of this individual was approximately twice that of an ordinary large individual, the length being $2,590\mu$, and the greatest thickness 55μ. The sluggish movements of the worm seems to make it improbable that it could come out of the root and travel any appreciable distance through the soil in search of another root, and up to the present time I have not found a single mature male worm of the genus *Heterodera* in the numerous water cultures of heavily infested soils that I have examined. Nevertheless the male worm possesses considerable powers of resistance towards desiccation and excessive moisture. Yet it does not seem possible that the female parasite could be fertilised by a male other than one which has developed in the same infected root.

Structure of the Male Worm.

The mature worm (Fig. 19) is thread-like in appearance and barely visible to the unaided eye, the length varying from 690μ to 2,590μ, with an average of 1,640μ (1.64 mm.). The thickness of the worm is fairly uniform, the average breadth being about 30μ. The extreme breadth of the largest specimen met with was 55μ. The anterior end is bluntly rounded, and the posterior end tapers slightly. There is no marked bursa copulatrix or genital wings. The cuticle is quite transparent and is traversed by transverse striations about 3μ apart. These striae are very prominent in the worm while still encased in the larval cuticle and can also be plainly seen when the worm is viewed *en profile.*

Anteriorly there is a definite *lip region*, consisting of what look to be six radiating papillae marked off from the main body by a slight but distinct constriction. The *spear* is about 23μ to 26μ in length, the anterior half tapering to a fine point. The three terminal knobs on the spear are very distinct. The spear occupies the entire buccal cavity, and is directly continuous with the lumen of the oesophagus.

The *oesophagus* is a fine, relatively straight tube, about 100μ in length. Its walls are overlain by protoplasmic granules, and the cellular structure of the muscle is not discernible. At the termination of the oesophagus is a thick-walled oesophageal (cardiac) bulb with a spherical lumen that, by alternately expanding and contracting, acts as a suction organ in connection with the spear.

The *intestine* occupies the posterior two-thirds of the body and has inconspicuous walls. The lumen of the intestine is relatively wide, and is more or less densely packed with protoplasmic food graules. The intestine opens to the exterior together with the aperture of the vas deferens in a common cloaca situated on the ventral surface about 20μ from the posterior extremity of the body.

The *reproductive organs* consist of two testes which extend through the body for a distance of 350μ. Usually the testes lie so close together and are so much obscured by the intestine that they are indistinguishable, but their double character, which is the subject of so much difference of opinion, can be more satisfactorily established when, as in the case of the specimen drawn in Fig. 19, the two testes are asymmetrically twisted so that their extremities become individually visible. As far as can be observed the testes appear to become contiguous and to coalesce posteriorly so as to produce a single vas deferens. Anteriorly the testes are composed of undifferentiated sex cells, but the posterior vas deferens contains full matured sperm.

The spermatozoa are irregular amoeboid masses of protoplasm, not provided with a flagellum.

Connected with the vas deferens are two slightly curved copulatory spicules. They can be protruded to some extent through the cloaca and are chitinous in nature. They measure 34μ to 39μ and have boss-like thickenings at their extremity for attachment.

The *excretory system* is best observed from the side. It consists of a single excretory vessel coming from the intestinal region and opening by a pore some 40μ behind the oesophageal bulb.

The *nervous system* is difficult to distinguish, the only indications of its presence being a few fibres, presumably representing the nerve commissure, a short distance behind the oesophageal bulb and just anterior to the excretory pore.

The full period of development of the male from the egg was found to be nearly four weeks, and the duration of adult life seems to be a little more than three weeks. In ordinary small galls, such as are found on the roots of fruit trees and shrubs, adult males are rarely to be found at the same time as the swollen gravid females. They probably perish soon after fertilising the young mature female.

Development of the Female.

The development of the female parasite closely resembles that of the male up to a certain stage, after which the metamorphosis becomes so peculiar that the final product of the striking changes that occur can scarcely be recognised as a nematode. The evolution of the females involves a retrogressive metamorphosis that is probably a direct result of the parasitic life adopted by the organism.

The larva destined to develop into a female undergoes the same process of general thickening that marks the early development of the male from which it cannot be distinguished until a relatively late stage.

Having assumed the form represented in Fig. 14, the contents of the body are seen to slowly shrink away from the larval skin and eventually a new cuticle is formed under the old one. Gonads, indications of which were occasionally visible as two small groups of cells with distinct nuclei, now commenced to become more prominent. They ultimately come to consist of two ovaries situated at the ends of two caecal tubes, the uteri, which converge and unite to form a short vagina, that opens to the exterior by a vulva in close proximity to the anus. While the gonads are developing, the separation of the new organism, replete with spear, alimentary canal, etc., inside the former larval skin is completed. The appearance of the mature female, as the animal now virtually is, still in its larval cuticle, is shown in Fig. 15 on Plate VII. The female now undergoes an ecdysis. The spear is employed to pierce the skin and the ecdysis that follows corresponds to the final one undergone by the male.

In both sexes the individual discards the old larval cuticle that is distinguished by having the posterior spine-like tail. Only two moults in the evolution of both male and female have thus far been observed, and I am unable to confirm the statement of Stone and Smith (1898) to the effect that four or five ecdyses occur.

The further development of the female consists of a gradual distension of the intestine in the posterior regions of the body

until the individual has assumed the shape of a club (Fig. 16). The anus and vulva become situated on a prominent protuberance at the extremity of the body. The anus, which opens to the exterior at the terminus of the short, narrow rectum, is quite terminal, while the vulva which is continuous with the vagina, though in close proximity to the anus, is slightly lateral in position. Both anus and vulva have tumid lips, and it can only be at this stage of the life history that fertilisation by the male is possible, for in later development the vulva disappears from view and the protuberance on which it was situated is absorbed into the general contour of the body.

The spear, which is 20μ in length, is in constant motion, and since the swollen shape of the body makes progression impossible the function of this structure can only be that of rupturing the walls of the neighbouring cells and absorbing the liquid contents. The young female (Fig. 16) at the time of fertilisation measures 460μ to 600μ in total length, the maximum thickness being approximately 230μ.

Structure of the Adult Gravid Female.

After the fertilisation of the young female, another period, again characterised by an increase in thickness, commences until finally the body attains the pyriform shape of the gravid individual as illustrated in Fig. 17. This thickening is now primarily due to the formation of eggs inside the uteri. The size of these swollen females ranges from 660μ to 750μ in length (average 700μ), while the maximum breadth varies from 400μ to 495μ. The "neck" region is relatively shorter than that of the female before fertilisation. In the parasite in the potato, which formed the main material for the present investigations, no traces of transverse striations were visible on the anterior "neck" region of the females, even when observed under the highest magnification, although these were always evident in the parasites of other roots, such as the snapdragon, *Antirrhinum majus*. Striations were also frequently visible in other parasites taken from infested potatoes grown in other localities. This point will be again referred to in the discussion of the identity of the parasite.

The *spear* is about 25μ in length and can be easily seen when moving. The oesophagus is sinuous and its bulb is relatively large, its diameter occupying a large part of the width of the "neck." Further details of the anatomy are obscured as a result of the body becoming overladen with food. The excretory duct and its pore have been recognised only in one or two instances. Its position is normal.

The uteri have undergone considerable torsion, and their coils are usually undistinguishable owing to the body of the organism being rendered opaque by its protoplasmic contents. The vulva has disappeared from view, and the anus can only be occasionally distinguished, surrounded by a less opaque area at the posterior spherical region of the body.

Gravid females taken from potatoes have been found to contain not more than sixty to seventy eggs in all stages of segmentation. Not infrequently a number of free larvae are to be found in the body cavity of the now deceased parent. Presumably the majority of the eggs develop and hatch in the uteri and the larvae migrate into the general body cavity whence they escape on the disintegration of the parental body. In the writer's opinion the female cannot be described as oviparous, since evidence of her depositing eggs is lacking. (*Cf.* Bessey, 1911.)

Identity of the Parasite.

Genus.—*Heterodera* (A. Schmidt, 1871) is defined by Railliet in his "Traité de Zoologie medicale et agricole," page 554, as a plant parasite nematode, the oesophagus having two bulbs, the anterior cylindrical, posterior spherical. No teeth; buccal cavity ovoid and contains a spear. Sexual dimorphism well marked. Male cylindrical and without bursa. Female globular, with symmetrical uterus. Metamorphosis complex.

Cobb (1902) states that *Heterodera* is similar to the genus *Tylenchus* in many respects, but differs mainly in the complicated metamorphosis which takes place in *Heterodera*. It also differs in that *Heterodera* possesses two testes in the male, species of *Tylenchus* possessing only one.

Two species of the genus *Heterodera* have so far been established, viz., *H. schachtii* parasitic more especially in the sugar beet, and *H. radicicola* (Greef Muller), which has a much more widespread distribution and a greater range of host plants. From the development of the parasite described in this paper the organism undoubtedly belongs to the *Heterodera*. The table presented below is a modification of one given by Bessey that has been slightly extended to include features not given in the original, and at the same time gives a comparison with the organisms under investigation. It will be seen that there are certain substantial points of difference which, in my opinion, cannot be ignored. Some of these appear to be intermediate between the distinguishing features of *H. schachtii* and *H. radicicola* and the question arises whether the organism in the potato can be regarded as a new species or whether, knowing that *Heterodera* is a plastic organism exhibiting numerous small variations, we are to look upon our organism as an extreme variety resulting from environmental difference and consequently not of specific rank. Up to the present time I have not been able to procure *H. schachtii* for comparison, as this species has not been obtained in South Africa, and so I am disinclined to pronounce any definite views. We must regard the parasite as *H. radicicola*, and take the view that differences such as the number of eggs, their size, and whether they are deposited by the female or not, can be reconciled with normal variation.

The table of comparison is as follows:—

TABLE OF COMPARISON.

	H. schachtii.	Species investigated in potato in South Africa.	*H. radicicola*, as found in Antirrhinum in South Africa.
Effect on host plant.	No galls.	Gives a warty appearance to potato.	Large galls produced.
Location of mature female.	External, anterior end only within root tissues.	Majority are close to the periphery.	Usually entirely within tissues of root.
Shape and external appearance of gravid female.	Mostly lemon shaped dull and flaky in appearance.	Mostly pear shaped, dull and transparent.	Pear shaped, glistening and pearly white.
	No trace of transverse striae on anterior portion.	No transverse striations.	Transverse rings of cuticle visible especially on anterior portion.
Eggs.	Partly deposited outside but mostly developing within the parent body.	Egg depositing has not been observed. Most of the eggs develop in the uterus.	All but last few are deposited outside body of parent.
	Average 80μ by 40μ (Railliet)	Average 92.4μ by 34.6μ.	Size 85μ to 88μ by 34μ to 40μ (In Antirrhinum average size 119μ by 43μ)
	Number?	Female produces from 60 to 70 eggs.	400 to 500 eggs produced by female.
	Enveloped in "eirsack."	No "eirsack."	Enveloped in "eirsack."
		Ellipsoidal and nearly symmetrical.	Kidney shaped.
Larvae.		Average size 350μ to 470μ by 13μ to 16μ, on hatching.	Length about 330μ.
	Spear 25μ.	Spear 11μ to 16μ.	Spear 12μ to 15μ.
		Movement—very slow.	Movement—active.
		Lived 32 days in water.	Lived for few days only in water.
Duration of development from egg.		Five days in moderate warm weather.	Two to three days in cool weather, less in warm.
Mature Male.		600μ to $2,590\mu$ in length.	$1,200\mu$ to $1,500\mu$ in length.
	Spear about 30μ.	Spear 23μ to 26μ.	Spear 24μ.
	Single testis.	In some specimens two testes which appear to unite posteriorly are evident.	Two testes (Cobb and Atkinson) Single testis (Bessey).

The Powers of Resistance of *Heterodera radicicola*.

The ova and larvae are the most hardy stages in the life history of *Heterodera radicicola.*

In a moist ambient the ova and larvae are able to exist for a prolonged period, providing temperature conditions are not extreme. On the other hand comparatively small variations from the natural conditions which obtain in the roots are fatal to the parasitic stages such as the developing and mature females. When immersed in water they often burst after an hour or so owing to osmotic pressure within the body, while they shrink beyond recognition when allowed to dry in a watch-glass. The mature males appear to be equally susceptible to desiccation but can remain alive in water for nearly two weeks. They would seem capable of living in moist sandy soil for a longer period, but I have not been able to ascertain this period as yet.

The isolated eggs hatch within a few days in water. The free living larvae have been kept alive for thirty-two days, the temperature during that period varying between 16°C. and 27°C. Drying was fatal in a very short time to isolated ova and young larvae. In the gall worm of the potato, where the ova are devoid of that protective covering or "eirsack" described by Bessey for *H. radicicola*, the ova shrivel up soon after desiccation in the open air and their protoplasmic contents become amorphous. These eggs cannot be revived by moistening and are incapable of further development. The free-living larvae, although more resistant as a result of the tolerably thick cuticle, are not invulnerable. After being exposed in a watch-glass for but a day, large vacuoles appear in the intestine. Larvae dried in this way for only about forty-eight hours could not be revived by immersion in water for a week.

Duration of the Life History of the Parasite.

The period necessary for the full development of the egg and the liberation of the larva therefrom is from five to six days in average mild spring weather in Johannesburg. Eggs removed from a gravid female were placed in a glass vessel with water and observed from day to day. By the fifth day many larvae were found free in the water, while on the sixth day no eggs remain unhatched. From observation made in the field it is evident that the larvae are able to survive for a considerable time, probably two years or more, if conditions in the soil are not adverse. However, should the larvae be able to gain access to the roots of a suitable host plant galls will usually appear within four or five weeks, showing that this period is sufficient for sexual differentiation, the fertilisation and subsequent swelling of the female. Experiments demonstrating this were carried out in seed-testing boxes, one side of which was of glass. Healthy tomato seedlings, beans and peas were planted in these boxes, which had previously been heavily infected with *Heterodera* eggs and larvae. After a few days the roots of the plants began to be attracted by heliotropism towards the glass side of the box

and were thus able to be constantly observed. Galls containing the gravid females commenced to appear on the roots, and wilting set in thirty days after planting the seedlings.

Mode of Infection by the Parasite and its Effect on the Host Plant.

The free living larva inhabiting the soil is the infective agent. It penetrates the young roots of the host, especially in the region of the tender-growing points, and aided by its spear, pierces its way into the vascular bundles and the surrounding tissues. The further development of the larva now takes place, leading, as has been shown to the fertilisation and swelling of the females until they attain the cyst-like form. The gravid females are usually found in groups and seldom occur solitarily. In the potato tubers they generally occupy an area about half a centimetre from the edge; in badly infested tomato and fruit trees roots they are found in large numbers even nearer the periphery.

The presence of the parasites in the roots acts as an irritant on the plant and leads to a rapid multiplication of the cells of the parenchymatous tissue. When the tissues of the vascular bundles are affected, the vessels grow around the parasites and consequently contortions of the course of the vessels are produced. The abnormal multiplication of the cells result in the formation of "galls" or "knots" which may be up to an inch in diameter and give the roots a much disfigured appearance and interfere with the circulation of the sap.

An attempt is sometimes made by the host plants to resist the future ravages of the parasite. The walls of the cavities in which the females are situated become brown, and, to a certain extent, lignified, thus tending to cut the parasites off from the adjacent tissues and to hinder any further migration on their part.

The interruption of the flow of sap due to the ravages of the parasite results in most cases, where the infection is heavy, in the stunting of the growth of the plant, the leaves often become wrinkled, gradually commencing to wilt and finally dropping off. It seems that it is not so much the actual diversion of the sap and plant juices which act as food for the parasites—for that is comparatively small—that is so fatal to the plant, as the physical irritation resulting from its presence which leads to the derangement of the vital functions of the roots. Further, the entrance of the larvae into the roots often allows the ingress of pathogenic bacteria, such as *Bacterium solanacearum* into tobacco and tomato roots, and the organisms causing the cotton disease known as "Blackroot" in Georgia, U.S.A., which do much to accelerate the fate of the host plant. Badly infested roots are often soft and pulpy at the site of infection. This may be due to the secretion of a toxic substance by the parasite which affects the tissues and facilitates the escape of the larvae into the soil. On the other hand, the decay of the root may also be caused by bacteria and fungi that are usually present.

Susceptible Host Plants.

The list of plants affected by root "knot" given by Bessey (1911) is a formidable one, containing over five hundred plants; the list has been added to by other workers, and a large proportion of the plants catalogued are of great economic importance. Indeed, very few of our cultivated plants are altogether immune from attack.

Many plant roots on inspection are occasionally seen to be somewhat disfigured by galls, which experience has shown can not always be regarded as due to gall worm (*Heterodera*) until the parasite has actually been isolated by microscopic investigation.

The presence of other nematodes, often species of the genus *Tylenchus*, is sometimes manifested in cultures made of root material infested by *Heterodera*. These worms often cannot easily be differentiated from the larvae of *Heterodera* as their gross morphology is identical with this genus. Their sizes and possibly also the rapidity of their movement, would appear to be the only means of distinguishing them. Thus, larvae of this nature were found in the pith cavity of the stem and in the roots of a snapdragon plant (*Antirrhinum*) which larvae were as long as 970μ, and 21μ broad. Others of similar structure, found in roots and soil cultures were only 200μ in length and 20μ in breadth, while the larvae of *Heterodera* vary in length between 345μ and 500μ, the average being about 360μ.

The following is a list of plants that the writer has personally examined and found parasitised more or less severely by *Heterodera* in South Africa.

It will be seen that most of the plants listed are cultivated either for food or for ornament.

Among tha few monocotyledonous hosts the presence of the mealie, *Zea mais*, is most important, for, as a rule, it has been thought by most authorities to be one of the few immune crops. In this case the mealie plants were found in an orchard where conditions were optimum for the thriving of the parasite, and, although the orchard was a new one, having been established for only three years on ground that was covered with bush and had never previously been under cultivation, most of the fruit trees were severely infested. It would appear that the parasite, under suitable conditions, is able to accommodate itself in most plants, and that strains or varieties of supposedly immune plants may occur which are not totally immune.

List of Host Plants.

Abutilon indicum.
Allium porrum—leek
Amaranthus paniculata.
Antirrhinum majus—snapdragon.
Beta vulgaris—beetroot.
Brassica campestris—turnip.

Cajanus indicus—dal, or pigeon pea.
Calendula officinalis—marigold.
Cannabis indica—"dagga."
Capsicum annuum—chillies.
Carica papaya—pawpaw.
Chenopodium sp.
Cucumis sativus—cucumber.
Cucurbita pepo—pumpkin.
Dahlia variabilis—dahlia.
Datura stramonium—"stinkblaar."
Daucus carota—carrot.
Dianthus caryophyllus—carnation.
Fagopyrum esculentum—buckwheat.
Ficus caricus—edible fig.
Helianthus annuum—sunflower.
Ipomoea batatus—sweet potato.
Lactuca sativa—lettuce.
Lagenaria vulgaris—calabash.
Lupinus sp.—lupin.
Lycopersicon esculentium—tomato
Lygustrum vulgarum—privet.
Medicago sativa—lucerne.
Nicotiana tabacum—tobacco.
Pastinacea sativa—parsnip.
Phaseolus vulgaris—bean.
Petunia hybrida—petunia.
Phlox sp.—perennial phlox.
Physalis peruviana—Cape Gooseberry.
Pentstemon wrightii—Pentstemon.
Pisum sativum—pea.
Prunus armeniaca—apricot.
Prunus domestica—plum.
Prunus persica—peach.
Ricinus communis—castor-oil tree.
Rosa setigera—rose.
Solanum auriculatum.
Solanum nigrum—nightshade.
Solanum tuberosum—potato.
Vitis vinifera—grape vine.
Zea mais—mealie cr maize.

Conditions Favouring *Heterodera radicicola*.

It has been noted that heavily infested plants, containing numerous *Heterodera*, often occur on loose, sandy soil, well supplied with water, so that the subsoil is constantly moist. A heavy lcamy-clay soil does not appear to be favourable to the parasite, and plants growing on such a soil would, consequently, be free from the pest to a large extent.

Geographical Distribution of *Heterodera*.

Heterodera radicicola has a world-wide distribution. The fact of its not having been reported from Rhodesia and other

parts of Africa is most probably due to lack of observation or of the publication of its presence in those countries. I have personally found the parasite in many farming districts in each of the four provinces of the Union.

As regards its origin, Neal is of opinion that it is indigenous to a large portion of the southern United States, and as evidence, states that he has found it "in many places in Georgia and Alabama where neither trees nor plants have been introduced from other sections."

The writer is also able to state that it is harboured by indigenous vegetation in several places in Natal that have never been under cultivation as far as knowledge goes. This might lead one to the opinion that the pest is also of ancient origin in South Africa were it not for the fact that it is easily possible in sandy soils for the eggs and larvae to be borne by wind and water streams from infested land. Thus, once introduced into a district, the parasite may be disseminated by natural means and indigenous vegetation in virgin soil be attacked.

Some Suggestions for the Control of Root "Knot" in South Africa.

The problem of the control of *Heterodera*, as well as of other nematode plant parasites, has engaged the attention of many able agricultural biologists for the past thirty years, but unfortunately their endeavours have not met with any marked measure of success. Attempts to mitigate the ravages often consequent upon infestation on a basis compatible with economy have been especially unsuccessful, and the writer has seen numerous large young orchards situated upon infected but otherwise ideal land, rendered almost valueless.

As has been previously indicated, the young which constitute the only stage in the life-history which is passed in the soil, unprotected by the roots, is capable of withstanding only a limited range of variability of conditions and will readily succumb if these limits be exceeded. Attempts to eradicate the pest must be aimed at the larva.

In America and elsewhere numerous experiments have been carried out to destroy the parasites. It is exceptional that nematode root parasites pass their free life at any great depth in the soil. They may be especially abundant in the first ten inches of soil, but they are seldom found at depths greater than about sixteen inches below the surface. Consequently, to deal adequately with the pest, it would only be necessary to destroy the parasite by treating the surface soil, but even this is a difficult task. To effect this, it has been proposed to subject the larvae to treatment by chemicals, steam, etc. These methods, even if they achieve their purpose with a substantial degree of success, could scarcely be adopted on as extensive a scale as is often required owing to prohibitive costs. Speaking generally, the chemical and other artificial fertilisers employed in practice in agriculture do not appear to have any direct effect. Lime, both

slaked and unslaked, calcium carbide, and other moderately inexpensive chemicals are of little avail. But it has been observed that trees and plants with a good ramifying root system do not, as a rule, show any obvious signs of disorder and consequently where valuable orchards are at stake, the use of phosphates and other fertilisers employed so as to stimulate an extensive root system and to induce deep-root growth, would be most beneficial. For deciduous orchards the heavy application of formaldehyde (one part commercial formalin to one hundred parts water) poured into a small trench round the tree when it is in a dormant state, is said to be advantageous. Other chemicals, such as carbon bisulphide, magnesium sulphate, sodium cyanide, sodium chloride, have been tried, but must be used in such concentrations that they become fatal to the young roots and often kill the tree. According to Professor Kuhn their use is not to be counselled.

Inundating the land for some time has been advocated by some authorities, but in view of the fact that the larvae are capable of surviving for over a month in a water medium little hope of success can be attached to the mode of treatment, even if it were practicable in South Africa. Steaming the soil by means of a system of underground pipes under a pressure of 40lbs. per square inch is said to have beneficial results, but here again practical economy will restrict this procedure to the hothouses and to small valuable plots.

The "trap-crop" method of controlling the sugar-beet parasite *H. schachtii* as devised by Kuhn at Hälle is well worthy of consideration. Essentially this method was based on the researches of Strubell on the life-history of *H. schachtii*. A highly susceptible "catch-crop," in this case a species of mustard, is thickly sown in an infested field in early spring. The development of the worm within the roots is constantly followed by microscopic examination, and the infected crop is uprooted before the new generation of larvae have had time to escape from the female (three to four weeks). This procedure perceptibly diminishes the number of parasites in the soil, and after two or three trap crops have been grown and destroyed the land can again be profitably employed for the growing of sugar beet. A considerable measure of success was obtained by the employment of this method in Europe, but when tested by Bessey for *H. radicicola* in America it does not seem to have yielded such favourable results. As yet our knowledge here in South Africa of susceptible and resistant crops is not sufficiently complete to allow of experimenting to the best advantage, but nevertheless this method is worthy of trial.

The principle of starving out the parasite in the soil also suggests itself, and conditions in South Africa in many cases would render it fairly simple. The infested land should be cleared of all crops and weeds that might act as hosts for the organism and either be allowed to lie fallow, or where possible, sown with a crop, such as the "iron" variety of cowpea, winter oats, or peanuts, that is immune to the parasite. Wheat (*Triticum aestivum*), according to Sorauer, is somewhat susceptible, and I

have found maize to be susceptible to some degree, but in practice both of these crops might be regarded as resistant and can often be grown profitably. The growing of either of these cereals for two or three years on infected ground might be a very practical way of dealing with the problem.

Desiccation is also very fatal to the parasite in all its stages. In South Africa, where the sun's rays are very powerful and the dry seasons are usually regular and sometimes prolonged, desiccation often occurs as a matter of course. Where this can be assisted by frequent ploughing and the use of unslaked lime in fairly heavy quantities, the result should be beneficial.

The presence of varieties or biological strains of *Heterodera* is sometimes suggested by the fact that in heavily infested plots the parasites often confine their activities to one particular kind of host plant in preference to others that have been shown to be equally susceptible to attack. This seems to indicate the possibility of the creation of slight strains of the parasite which, once having accustomed themselves to a special type of host, tend to prefer it to other plant hosts. In the same way resistant varieties of plants, such as the "iron" cowpea, may be simultaneously evolved. Further and prolonged investigation will be required before this hypothesis can be confirmed.

Other curious phenomena occur connected with the habits of *Heterodera* which make the study of the problem even more interesting. On several occasions it has been observed that plots which have shown themselves to be heavily infested with the parasite have quite suddenly become free of the pest without their having been specially treated in any way. Further, they have not reappeared when very susceptible crops were subsequently grown. It is difficult to explain these occurrences on any climatic basis, but it is possible that the mystery may be cleared up by a thorough investigation of the fauna and bacterial flora of the soil.

In conclusion, it may be a platitude to remark that, in view of the difficulty entailed in the control of the pest the old adage of prevention and cure should be the guiding principle of all gardeners and horticulturists. Great precautions should be observed in the introduction of new nursery stock that cannot be guaranteed free from *Heterodera*, and seed potatoes, whereby in agriculture the organisms are often spread, should be carefully examined before planting.

Acknowledgments.

I wish to acknowledge the general assistance that many friends have given during the course of these investigations. Primarily am I indebted to Professor H. B. Fantham, of the Department of Zoology, University of the Witwatersrand, Johannesburg, and to Dr. Annie Porter, of the South African Institute for Medical Research, Johannesburg, for their kindly interest and encouragement. I desire also to acknowledge gratefully the numerous facilities given me by many officers of the Divisions of Entomology and

Botany. My hearty thanks are also due to the Research Grant Board, for their grant-in-aid, which facilitated the collecting of material and conducting the investigation.

Summary.

(*i*) The structure and development of *Heterodera radicicola* is described and figured for the first time in South Africa. The occurrence of only two ecdyses in the course of development is established: one taking place when the larva is living free in the soil, and the second during the differentiation of the two sexes within the root of the host. For the most part the material used in these investigations was obtained from parasitised potatoes, and this organism was seen to differ substantially in some characters from *H. radicicola* found in tomato plants and others. These differences are detailed, but it is thought that they may be variations due to environment and may not be of true specific value.

(*ii*) The species *Heterodera schachtii* and *H. radicicola* are discussed and their differences tabulated, and they are compared with the parasite found in potato tubers.

(*iii*) The pathogenicity of the parasite and the mode of infection is discussed. Some susceptible host plants found in South Africa are listed. The geographical distribution of the parasite is set forth.

(*iv*) The methods of controlling the pest are briefly reviewed and an attempt is made to estimate their relative values in South Africa.

References.

All the references to literature contained below have been seen by the author. For a more extensive bibliography the work of Bessey (1911) should be consulted.

Atkinson, G. F.: "A preliminary report upon the life history and metamorphoses of a root gall nematode, *Heterodera radicicola* (Greef Muller) and the injuries caused by it upon the roots of various plants." Agric. Expt. Stn., Alabama Polytechnic Inst., Auburn, Ala. Vol. I., No. 1, December, 1889. Bull. of Agric. Expt. Stn. n.s., No. 9, 1889; 54 pp., 6 pl.

Bessey, Ernest A.: "Root Knot and its Control." Bull. 217, Bureau of Plant Industries, U.S. Dept. Agric., 1911. 81 pp., 3 pl.

Cobb, N. A.: "Root Gall." Agric. Gaz. of New South Wales, Vol. 13. Sydney, 1901.

"Fungus Maladies of the Sugar Cane." Bull. 6 of the Expt. Stn. of the Hawaiian Sugar Planters' Assn. (1909), pp. 51-62.

Lounsbury, C. P.: "Gall Worms in the Roots of Plants. An important potato pest." Circular 25. Cape of Good Hope Agric. Dept., 1904.

ORTON, W. A.: "The Wilt Disease of the Cowpea and its Control." Bull, 17; pt. 1. Bureau of Plant Industries, U.S. Dept. Agric. 1902.

ROLFS, P. H.: "Diseases of the Tomato." Bull. 47. Florida Agric. Expt. Stn. September, 1898.

STONE, G. E. and SMITH, R. E.: "Nematode Worms." Bull. 55, Hatch Expt. Stn. of Mass. Agric. Coll. November, 1898.

SCOFIELD, C. S.: "The Nematode Gall Worm on Potatoes and other Crop Plants in Nevada." Circ. 91, Bureau of Plant Industr., U.S. Dept. Agric. Issued February, 1912.

EXPLANATION OF PLATES VI-VIII.

All figures were drawn by the author with a camera lucida and Zeiss drawing table.

EXPLANATION OF LETTERS USED IN FIGURES.

An.—Anus.
Ct.—Cuticular striæ.
Exc. Pr.—Excretory Pore.
Int.—Intestine.
Oes. comm.—Oesophageal nerve commissure.
Oes.—Oesophagus.
Oes. blb.—Oesophageal bulb.
Ov. rud.—Rudiments of Ovary.
Rect.—Rectum.
Cap. spic.—Copulatory spicules.
Testis.—Testis.
Vlv.—Vulva.

PLATE VI.

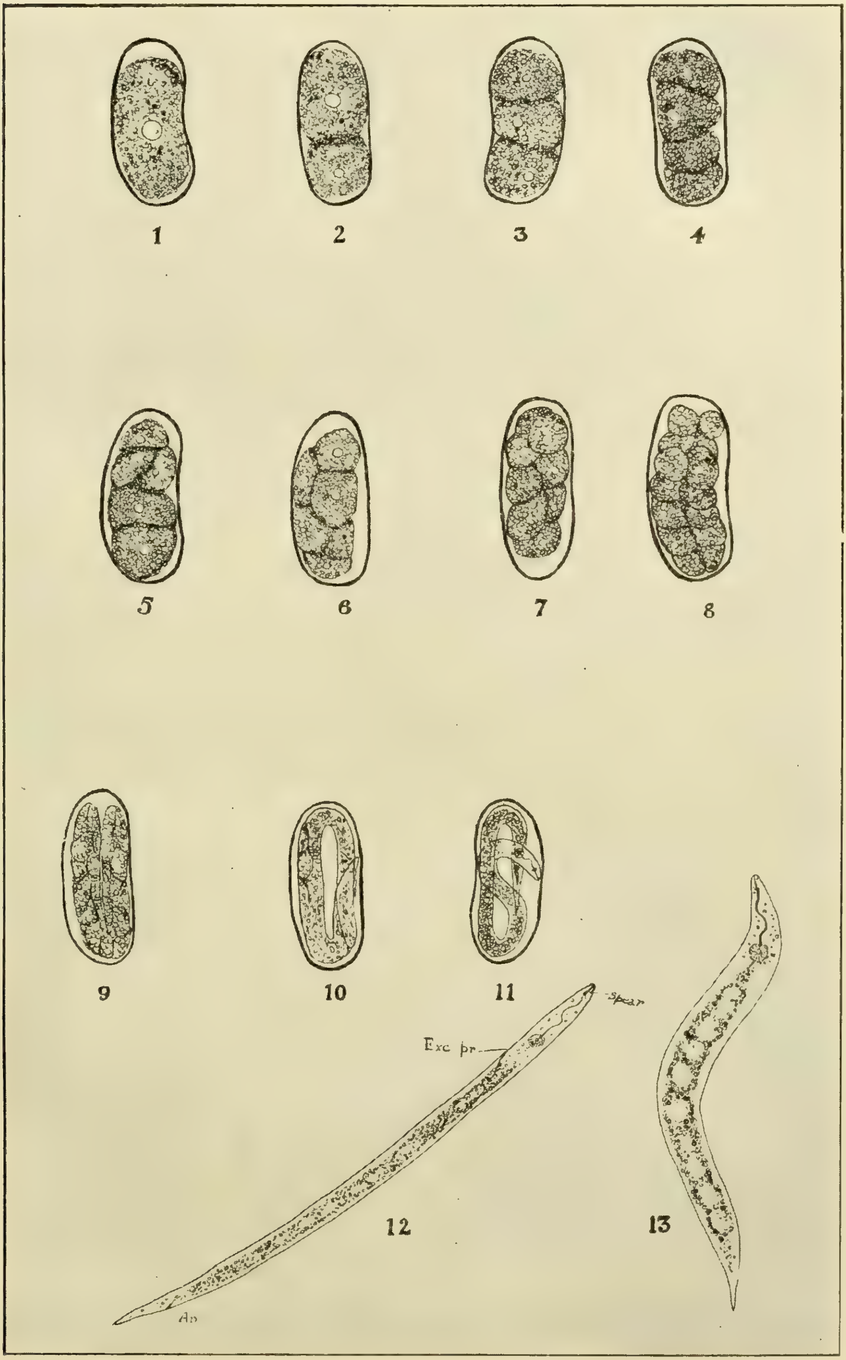
Figs. 1—10: Eggs of *Heterodera* from potato in different stages of development. × 250.
Fig. 11: Embryo just prior to hatching. × 250.
Fig. 12: The free-living larva. × 250.
Fig. 13: The parasitic larva just commencing to swell. × 250.

PLATE VII.

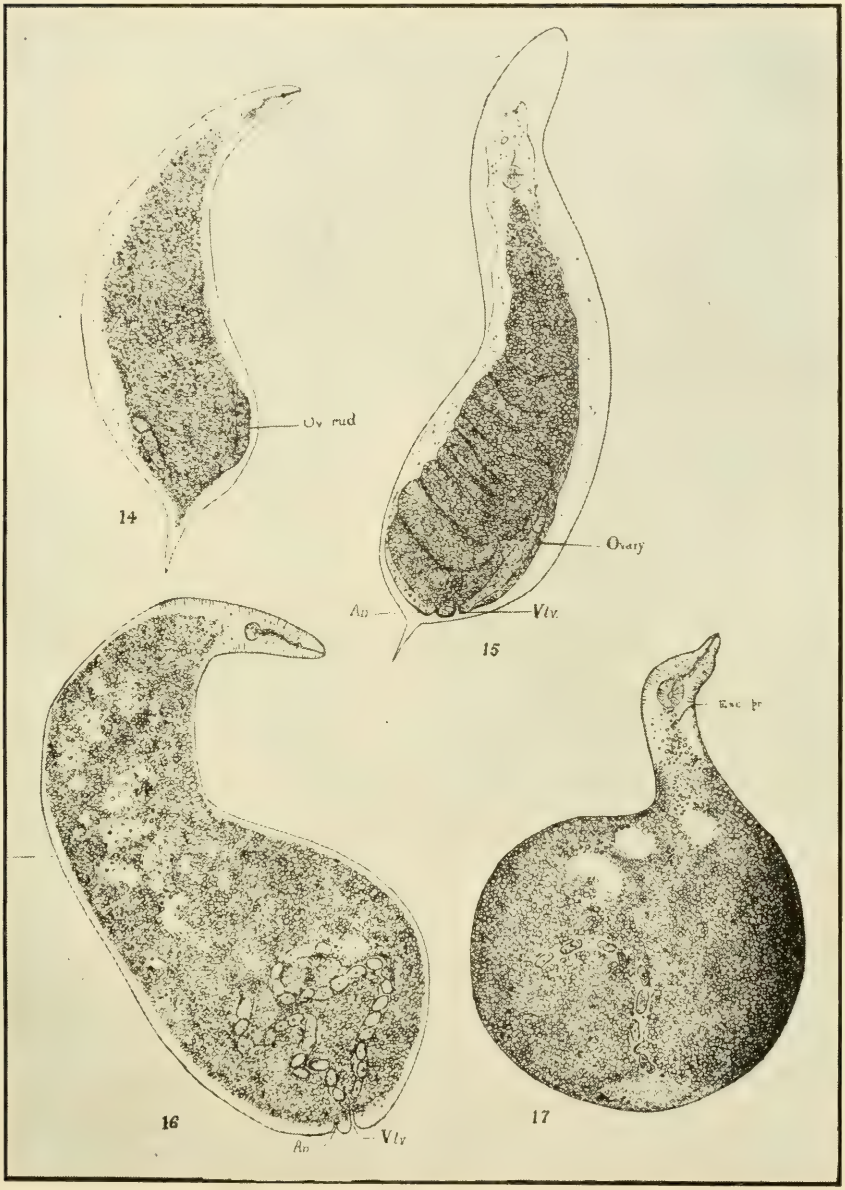
Fig. 14: Parasitic larva at commencement of sexual differentiation. × 250
Fig. 15: Immature female still within larval skin. × 250.
Fig. 16: Mature female after casting larval skin. Ovary showing and external orifices of vulva and anus visible. × 200.
Fig. 17: Mature gravid female containing eggs. × 95.

PLATE VIII.

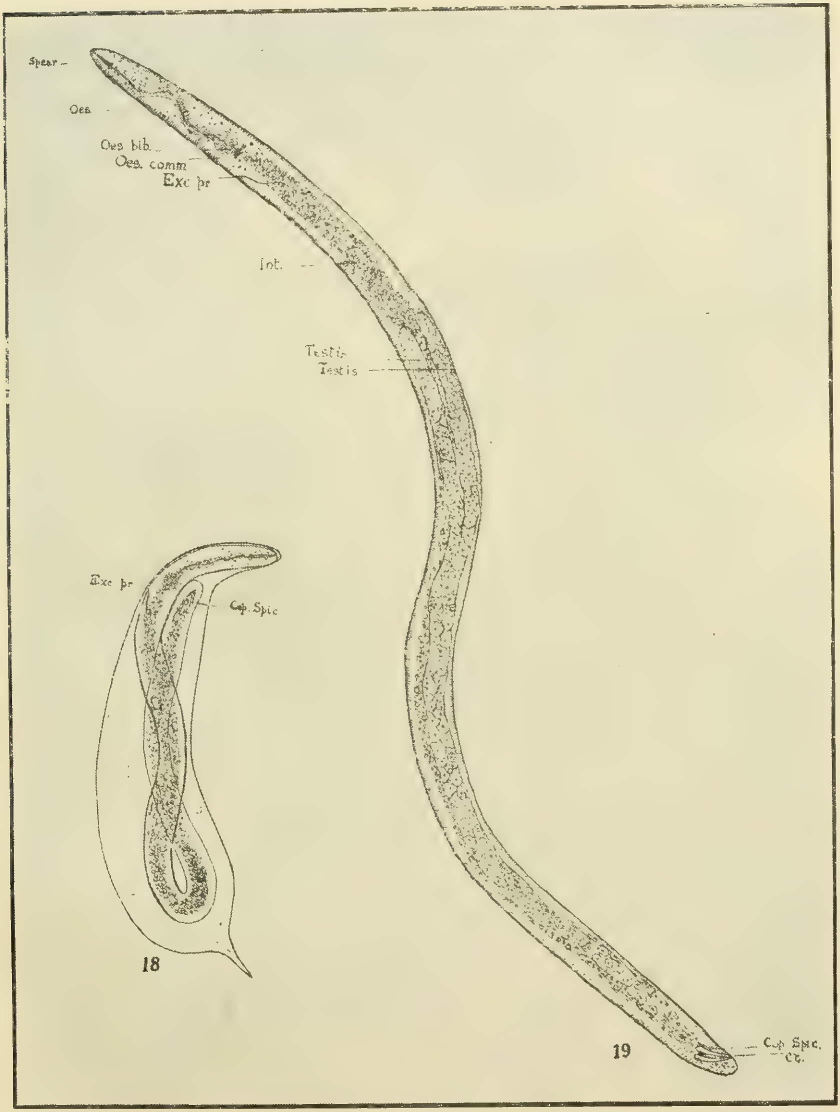
Fig. 18: Fully formed male still encased in larval skin. × 150.
Fig. 19: Free mature male. (This specimen shows the double nature of the testis). × 150.



HETERODERA RADICICOLA.



HETERODERA RADICICOLA.



HETERODERA RADICICOLA.

THE NATIVES AND AGRICULTURE.

BY

W. HAMMOND TOOKE.

Read July 13, 1921.

"Les pays du pâturage sont peu peuplés parce que peu de gens y trouvent de l'occupation; les terres á blé n'occupent plus d'hommes."—Montesquieu: "De l'Esprit des Lois." liv: XXIII, Chap. 13.

The Bantu tribes situated South of the Zambezi and the Cunene rivers are divided by scientists into five groups. The fifth comprises the Ova Herero and Ova Mpo; of which the former have recently been practically extirpated by a civilised soldiery more savage than the most bloodthirsty African warrior. The population of the other four groups may be estimated and distributed as follows:—

	Union.	Non-Union.	Total.
A. Zulu Kaffir:—			
Union	2,658,000[1]		
Swaziland		1,000,000[2]	
Portuguese East Africa		780,000[2]	4,438,000
B. Tekeza or Thonga:—			
Portuguese East Africa		1,000,000[2]	1,000,000
C. Kalanza:—			
Southern Rhodesia ...		750,000[3]	750,000
D. Bechuana:—			
Union	1,282,000[1]		
Basutoland		400,000[4]	
Bechuanaland Protectorate		120,000[2]	1,802,000
	3,940,000	4,050,000	7,990,000

When the Fecani wars, originated by the Mtetwa tribe, had gradually subsided, most of the tribes north of the Orange River were recent arrivals, driven here and there, fugitive and vagrant, or placed by the emigrant Boers on the locations assigned to them. It is not necessarily to be inferred that the latter were thus established either lawfully or by due authority, or by any other right than the arbitrary will of the strongest.

The Bechwana (including the Basuto), who cover the largest extent of territory with which we have to deal, occupy the eastern part of what is called by botanists the "Kalahari region," a wide outland basin drained by the Orange River and its northern tributaries. It embraces that portion of the Cape Province north of the Orange, which used to be called "Griqualand West" and British

[1] In round numbers based on the Union Census of 1911.
[2] Estimated.
[3] Including a number of Matabele which belong to Class A.
[4] Lagden's "The Basutos."

Bechuanaland, as well as the Waterberg and that part of the Transvaal lying South and West of the Magaliesberg Watershed. It is for the most part devoid of trees, interrupted at great distances by a few isolated flat-topped mountains. On these hills grow a few stunted bushes such as the "buchu" (Barosma) and "bitter-boschje" (Chrysocoma); the vleis and shallow valleys are tussocks of "rooi-gras" (*Themeda triandra*) and "twa gras" (Aristida).

A portion traversed by the richer valleys of the Vaal, Modder, Hartz, Molapo and Moletsane, northern tributaries of the Orange, is supplied with water during a rainy season which produces a rainfall averaging 18 inches to 22 inches per annum. More to the west the Kuruman and Okavango are only flooded by tropical thunderstorms coming from the north, and long periods of drought prevail.

The eastern or mountainous part of the "Kalahari region" unites with the western half of the sub-tropical or east coast region in a rugged and rock-riven complex of buttresses and bastions culminating in the Mont aux Sources on the Natal-Basutoland border and the Spelonken of the Transvaal. Here for half a century was the theatre of war between Sutu and Zulu in which the wielder of the battle-axe soon fled before the javelin of his shield-protected foe. Some of the mountain clans were reduced to cannibalism; others sought refuge in the caves and krantzes of the Drakensberg. In more peaceful times an ample and timely rainfall enables these fragments and remnants of tribes to grow small patches of mealies in the narrow but fertile valleys irrigated by streams of running water. But generally the ground is too poor and rugged for cereal culture on a large scale. In the Springbok Vlakte, it is true, there are enormous flats, but the soil is peaty and tillage as difficult in the rains as in the drought.

In the so-called Kalahari "desert" (Bechuanaland Protectorate) extend vast level grassy prairies or savannahs interspersed with patches and stretches of dense low forest, formerly abounding in and still frequented by hartebeeste, wildebeeste, gemsbok, giraffe, zebra and ostrich.

The Ngami lake and Makharikhari saltpans, fringed by reed and willow and supporting a prolific bird life, pelicans, flamingoes and other water-fowl, are but breaks in the rolling series of downs carpeted with a sweet nutritious herbage or cluster of bushy composite shrubs and interspersed with vaal bosch[1] and the kameel doorn mimosa[2], which lends to the open country a gracious park-like appearance.

The existence of underground "sand rivers" like the Mashowing and Setlagoli indicates a period when the rainfall was more abundant and streams, now mere wadys or flumaras, once were rolling rivers. In the vicinity of these old river-beds may be found good grazing grounds. So elsewhere the "sand-veld" thickly covered with acacia has a deep rich soil and yields good pasturage.

---

[1] Atriplex.
[2] Acacia horrida.

This region is healthy and suitable for cattle, and the "high veld" and Gordona are eminently suitable not only for horned stock but for sheep and goats.

The Bechuana seem to have obtained their sheep from the Korana. The domestic sheep found by the Dutch settlers among the flocks of the nomadic Hottentots were most likely an indigenous breed, for with their lop-ears and long fat tail they differed much from the fat-rumped, black-headed Persian or Hejaz breed found in North Africa and the Sudan. A good slaughter animal, it has been crossed with the merino for the sake of the wool, and this strain proves itself a valuable animal well suited to its habitat, equally welcome to the shearing house or the butcher's pen.

The Bechuana or Briqna, as the Hottentots used to call them*, were essentially a nation of goat-herds, but the goat they domesticated was introduced from the East if philological evidence may be trusted.

The Bechuana probably brought with them from their cradle in Northern Africa the indigenous African ox of which the Mima or Callal is the type; a large, long-legged, slab-sided beast with light hind-quarters and enormous horns, but lacking a hump—a good forager, a good trekker, but a poor milker. This animal closely akin to the Hottentot breed (also probably of Northern origin) is found in Abyssinia, Uganda, the high plateaux between the Nyanzas and Tanganyika and in Damaraland. It is the dominant type from the Zambezi to Table Bay. The Afrikander ox of the Boers is of the same breed, crossed two centuries ago with the Spanish or Portuguese ox, and in more recent times with the Friesland of Germany and Holland. The small hump borne by the bull might point to a cross with the East Coast humped breed or zebu. It is not, however, a true hump or flesh protuberance, but "merely a muscular enlargement of the wither."[1] "For a general breed it would be difficult to surpass this hardy, long-horned breed which has successfully adapted itself to its environment."[2] If it is true that "the production of oxen for transport work is practically dead,"[3] still this ox in its own country furnishes better beef than many imported beasts, and crossed with the Friesland yields a very fair supply of milk.

Some of the Bechuana tribes, such as the Bakolong and Bakwena, have displayed moderate skill, though much inferior to the Oriental races, in such industries as wood carving, smithy

---

* The Kora-Hottentot word Briqua, Biri-na applied to the Batlapin means "goat people." The word *Bili*, Sech. *puri*, Makua, *puri* Yao, Swahili, and *mbuzi* in nearly all Eastern Bantu dialects is traceable to a Persian or Arab origin, *buz*. The Zulu-Kaffir has two terms for goat, *mbuzi* and *impongo* (he goat); the latter found also in Thonga, Tonga, Rozwe dialects may have denoted an indigenous breed. In Zulu-Kaffir the term is confined to "he-goat."

[1] R. W. Wallace, "Farming Industries of Cape Colony," p. 254.

[2] Owen Thomas, "Agricultural and Pastoral Prospects of South Africa," pp. 201-3.

[3] C. G. Lee, address, May 15, 1907, as President of Agricultural Union.

work, basketware and pottery, while others carried their rude manufactures round from tribe to tribe as traders and pedlers; but in this respect they showed less of commercial spirit than the Bantu living on the banks of the great Congo and its river system. In the former days of plenteous rainfall grain-growing was one of the chief means of subsistence among the Bechuana, only checked by the extensive ravages into the rich fields of millet and sorghum of the hippopotami who then lurked in the zeekoe gats of the Kuruman and Marikwa. The frequent or prolonged droughts now restrict the Natives to such grain crops as Kaffir-corn and mealies (maize), the former a crop requiring repeated weeding and thinning.[1] The latter is a comparatively recent introduction welcomed as immune to a great extent from the voracity of finches and other graminivorous birds. In localities favourable to agriculture the Natives flock together, building their kgatlas and kraals into large "Stads" (Shoshong, Koloberg, Palapye), containing a population of many thousands. Here some tribes (e.g., the BaNguaketse) store their grain in enormous earthen jars, differing in this respect from the Kaffirs, who bury the season's grain in underground silos beneath the cattle-kraal. Failure of crops has, however, often compelled the unlucky grain-grower to rely for subsistence on his cattle depastured on the sunburnt veld, "arida nutrix leonum."[2]

On the whole, although the Bechuana doubtless employ much of their time in supervising their Bushmen cattle-herds, and in visiting their cattle-posts, they may fairly be described as an agricultural people. According to the schedule to the Native Lands Act of 1913, the total extent of land in the Union on which they are now located as agriculturists and pastoralists is about 2½ millions Cape morgen, of which the Bechuana occupy about 1,195,316 and the Basuto about 1,315,889 morgen.[3]

In Zululand the Government holds some two million morgen[4] reserved for the use of the Natives. Of this, however, they cultivate little more than two-thirds by growing maize, Kaffir-corn, and pumpkins. A large extent of the country is uninhabitable, being marshy and covered with rank herbage; that on the hillsides is of poor quality for agriculture.[5] The Province of Natal, together with that portion of the Cape Province known as the Transkeian Territories, forms a succession of grass-covered terraces ranging from the sea to the foothills of the Drakensberg; and the country is well adapted for stock-raising. The Zulu are almost entirely pastoral; their ideas, language and occupation exclusively bucolic. According to Mr. Owen Thomas the Natal Kaffir "is a

[1] Arbousset, "Narrative and Explanatory Tour," p. 64.

[2] In former days lions were not only as fierce and cunning as the "Man-eaters of Tsavo," but so numerous as to compel powerful Bechuana tribes like the BaHlakoane to build stone kraals and huts; the latter with pavements in front to prevent these hungry carnivora from orrowing under the door.—Ellenberger, op. cit., p. 71.

[3] See footnote 1 on p. 424.

[4] 3,887,000 acres.—J. Stuart, "Hist. of Zulu Rebellion," 1906, p. 16.

[5] J. G. Gibson, "Hist. of Zulus," p. 243.

lazy and immoral class, much under-taxed and pampered," the consequence, probably, of its having been protected by Farewell's party and the English colony from the tyranny of the Zulu despots. The Fingo refugees show some aptitude for a sort of peddling trade.

Generally speaking, the tribal system involving collective responsibility and collective possession[1] has inculcated habits of combination or mutual assistance which, as Mr. Dudley Kidd puts it, constitute "socialism."[2] Unlike, therefore, the isolated and individualistic Boer farmer, who either avoided or quarrelled with his neighbour, the Kaffir recognises the necessity of co-operation in such matters as the dipping of his sheep, the inoculation of his cattle and the destruction of locust swarms. Hence, when unity of action is demanded, the flocks and herds are better kept immune, or the contagious disease or noxious insect eradicated more quickly and effectively by the Native than by the European. Moreover, the simple Kaffir has his own method of curing disease and promoting vegetative growth gained through many generations from an inherited experience and application of the system of "trial and error," which, though not based on the science of the schools, should not be too readily despised by the agriculturist.

The Zulu breed of oxen forms a marked contrast to that of the Bechuana and Hottentot. They are diminutive, graceful animals with small humps, indicating that they were formerly introduced into the East Coast from India or Persia, being descendants of the zebu. Among the Xosa Kaffirs they seem to have interbred with the Hottentot variety, and with excellent results, for the writer does not remember having seen more beautiful and symmetrical oxen than those belonging to the Gcaleka chieftains depasturing the hill-slopes of the Transkei at the outbreak of the 1877-8 War. The Kaffir really breeds, not for slaughter, for he lives on milk and mealies and only slays an ox when avarice allows or ceremonial enjoins; nor did he use oxen as beasts of draught though he employed them once as beasts of burden (pack-oxen). The plough before the arrival of the white man was unknown. In its place he used the hoe. Cattle were, in fact, the form in which he liked to realise his wealth, to be parted with only in exchange for wives.

The Xosa-Kaffir also kept a few sheep, but he acquired them with his Hottentot wives, together with his name for them, *igusha* (Hott. *gusa*)[3] a term now applied to merino sheep to distinguish them from Cape sheep.

---

[1] "Land Tenure and Criminal Law of the Kaffirs and Anglo-Saxons," Révue Coloniale et Internationale, Vol. II., pp. 81, 86.

[2] "An organisation of society in which the means of life, whether production, distribution or protection are held in collective ownership." —"Kaffir Socialism," by Dudley Kidd, p. 3, note.

[3] C.f. KiHiau, *ngoza*. The word for sheep varies in almost every Bantu dialect. The following: Zulu *umvu*, Sechuana *nku*, Otyi-Hereo *Ntu*, Hambunda *ongue*, are akin.

The area in the Union occupied by the Zulu-Xosa tribes according to the schedule to Act 27 of 1913 amounts to about eleven million Cape morgen, as follows:—

Kaffirs in Transkei and Eastern Province ...	3,282,367 morgen
Fingos in Transkei and Eastern Province ...	585,747 morgen
Abambo in Transkei	723,669 morgen
Abambo and Zulu, Natal and Zululand	6,350,403 morgen
Zulu in Transvaal	155,726 morgen
	11,097,912[1] morgen

Our acquaintance with the Kalanga groups dates back to the commencement of the occupation by the Portuguese of Sofala (1505) and their conquests in the "empire" of the "Monomotapa."[2] The Makalanga are, or were, a race of exceptional intelligence and oriental blood, to whose skill is owing, probably, the extensive irrigation canals on Inyanga. The climate they enjoy is sub-tropical, enabling the natives to cultivate orange and lemon trees which are now found growing wild, but which had ceased to be cultivated at the time of Livingstone's visit; and it is doubtful if they were planted by Bantu.[3] There is no doubt, however, that up to the beginning of the last century they grew sugar-cane, beans, ground-nuts, pumpkins, melons, a kind of millet called *onunga*, which had the advantage of being untouched by locusts, and the recently introduced maize. The Matabele mostly grow Kaffir-corn (mabele) nowadays; *poko*, a kind of millet, is the favourite grain of the Mashona. The ravages of the Zulu hordes caused this unwarlike folk to flee to the granite kopjes for refuge, among which they grew small patches of maize and pumpkins scarcely sufficient for their subsistence.[4]

Matabeleland and Mashonaland as grass countries are superior to most parts of South Africa. Matabeleland pasture is close and sweet. Mashonaland grass is longer and coarser. Mashonaland is more suitable for agriculture; Matabeleland stands unrivalled for stock-raising.

In the past the Makalanga seem to have kept but few cattle, on account probably of the tsetse-fly, which haunts the low-lands and river-banks; but higher up in the Zambezi valley the Batonga (Batoka) kept a small but shapely breed resembling our shorthorn.[5] The Barotse again evidently got their stock from a Bechuana

[1] These figures are only approximately correct, as it is not possible to ascertain with any degree of precision the exact area allocated respectively to Zulu, Kaffir, Alambo, Basuto or Bechuana. The number of morgen per head reserved for Natives approximately, in British Bechuanaland is 15.5; Transkei, 4.4; Cape Proper, 1.1; Natal, 3.1; Transvaal, 1.7; Orange Free State, 0.2.—H. Mentz, vide Hansard, 1913, col. 2453.

[2] "Di Benomotapa e grande imperio," Camoens Lasiad x qb.

[3] R. H. Hall, "Prehistoric Rhodesia," pp. 395, 417, 418.

[4] Owen Thomas op. cit. pp. 260, 275, 229.

[5] In old debris heaps and under cement floors of the Zimbabwe ruins are found horns of a dwarfed short-horned ox smaller than the Guernsey. (*Bos longifrons?*) Hall & Neill, "Ancient Ruins of Rhodesia," p. 153.

source, probably through the Batwana of Lake Ngami. The indigenous Mashona breed on the other hand resembles the Angoni or Galla; it is a small and hardy animal more suitable for the granite soils of Mashonaland than the larger breeds.[1]

The Bathonga coast race dwell generally in forest country—ill adapted for stock-raising. The Bilene and Khosine, indeed, in days gone by, were grazed by many herds before the advent of *Glossina morsitans*, and the introduction of numerous stock diseases (redwater, rinderpest, East Coast fever), which have swept over the land and contributed to the abandonment of pastoral pursuits, save the keeping of a few goats.[2] Wives were formerly exchanged for oxen, but nowadays the lobola is paid in hoes as a medium of exchange; and it is presumed that the legal problems arising from "natural increase" no longer perplex the Thonga mind. But most of all the ravages of Swazi, Vatwah, Gaza, Shangaan, Matabele, and Zulu, who allowed none but themselves to possess any cattle, have caused the poverty in horned stock of the Kalanga and Thonga tribes.

The BaThonga grow sorghum, millet, maize, sweet potato, melons, peas, beans, ground nuts, and tobacco in little garden patches on the borders of the forest; and their aptitudes are clearly towards horticulture and market-gardening.

"The bulk of the two races, the European and the Native, "should live in the main in separate areas. . . . Social contact "should be reduced to a minimum."—Hon. J. W. Sauer, Hansard, 1913, cols. 2270, 2288.

Senator H. G. Stuart, in giving evidence before the Native Land Commission[3] recommends that in carrying out segregation "a careful note be taken of tribal conditions (misprinted connections)." Similarly Sir William H. Beaumont in his Minute to Government says, "due allowance has to be made for the great differences which exist not only in the nature of the land in different parts of the Union, but also in the language, the national spirit, the traditions and customs, the social status and the environment of the various native races."[4]

We cannot recognise too fully the importance of this injunction. It is not too much to say that it has in the past been practically ignored by the higher governing authorities, although obvious to local officials[5]: and a desire for uniformity has led to bureaucratic methods being applied to native administration, without consideration for the character, milieu, or tribe of the social unit. The same measure has been dealt out indiscriminately

[1] Owen Thomas op. cit. pp. 260, 275, 229.

[2] "The Natives knew of no stock disease until foreign cattle came." O. Thomas, Ibid. p. 33.

[3] Union Government, 19-16, Vol. I., p. 78.

[4] Union Government, 25-16, par. 127: for "races" read "tribes."

[5] Yet "how little the officials in one district know about the natives of the adjoining tribes; they seem to think that their very local experience of one set of natives entitled them to argue from the particular to the universal," Dudley Kidd, "Kaffir Socialism," p. 136.

to Gaika and Fingo, to Mopeni and Mollapin. When there have been differences of treatment they have been made (as in the case of the franchise) to suit the varying conditions of the white man rather than the black.

This would not have happened if the tribal system had been recognised and maintained—if the native had been ruled through his hereditary chief, and if we had realised the sacred character of lineal descent from the semi-divine tribe founder in the mind of the native, and the religious authority conferred by it upon the ruling chief and imposed on his subjects. It is much to be regretted, therefore, that the British Government did not (as it did in India after the days of the Marquis of Dalhousie) from the very first regard the Kaffir or Bechuana chief as responsible for the enforcement of a righteous, enlightened and effective rule under pain of deposition from office and substitution of a better qualified scion of the hereditary line.[1] There was excellent material available—men like Tao, Makaabe, Setyeli, Tulare, Motlume, Sekwati, Molitsane, Moroko, Rarabe, Sarili, and preeminently Khama and the house of Moshesh.[2] To such could have been entrusted, as is now done in the Protectorates, the task of distributing the pastures and sowing lands among the tribesmen; carrying out measures against animal diseases and insect pests, settling the date of seed-time and harvest as the Hurutse chiefs were wont to do for all the Bechuana tribes, adjudicating on questions of native marriage inheritance, and generally administering law and order as their fathers did in their day and in the old time before them. But of course we except the ceremonies of witch finding and rain making which are happily now obsolete or obsolescent. Nowadays the witch doctor and rain doctor may be replaced by scientific experts on agricultural matters who convey advice, instruction, and injunction through the British resident.

Unfortunately the ruling idea in the past was not to improve the native but to convert him—not to help him as a black man but to change him into a white one—to make him like ourselves—as near as possible. The Ethiopian had to change his skin. By "breaking down the power of the chiefs," however, a very salutary control was lost, adapted to the customs and prejudices of the tribe, which were often, as we have seen, originally the dictates of observation and experiment based on the inductive method. Had this course been pursued the prospect visioned by Mr. B. K. Long of "two harmonious and contented races in territorially separate area" might have been realised.[3]

---

[1] The fatal policy of destroying the power of the native chiefs instituted by Lord Charles Somerset, and for so many decades so greatly in vogue, was not long approved by Sir B. Durban. "I very much altered this opinion afterwards," he notes in a letter to Sir H. Smith. I., 1835.

[2] To say nothing of Sebituane, Moselekatse, Dinigiswayo and Cetywayo. Tshaka and Dingaan were merely butchers—Gaika, "cruel and treacherous"; Hintsa, the same; Saril (Kreli) "a gentleman," teste the late Archdeacon Woodruffe—a good judge.

[3] B. K. Long, Hansard, 1913, col. 2403. "It was a great mistake when they broke down the tribal system," J. Searle, Hansard, 1913, col. 2490.

Climate and terrain are of course fundamental. Human effort cannot alter them except perhaps by tree planting on an extensive scale; but irrigation may here and there ameliorate local conditions to a restricted extent. Without it, wheat grown on dry land in any part of South Africa is liable to rust and mildew. Oats is a better crop, but maize and Kaffir-corn can be grown in any soil; but a deep cultivation does not answer and the native who scrapes up three or four inches succeeds better than the European with his deep-soil plough.[1] The rhenoster bosch is said to be a good indication of wheat-growing soil,[2] just as mimosa grows when there is the nutritious sweet veld. Broadly speaking, the plateaux of the northern parts of the Union form excellent cattle ranches.

A stock-raising country can, however, only support a sparse population. That of Griqualand West and British Bechuanaland average 25 morgen a unit. The best form of tenure, therefore, for the Bechuana reserves is the tribal or communal tenure, which is certainly not to be condemned, because, as Sir W. Beaumont says, "it leads to the preservation of the tribal system and the power of the chiefs." This is rather an argument in its favour as showing that it was fitted to the native mind and native life. Dr. Theal calls it an admirable system of land tenure for people in their condition,[3] and Mr. Dudley Kidd shows that "on the tribal system of land tenure, poverty is virtually impossible. All land is the property of the tribe for whom the chief acts merely as trustee: he cannot alienate without the consent of his council. . . . The grazing land is common to the whole clan; the arable land is distributed by the leading headman among the tribe; the allotments are inalienable"—that is so long as they are beneficially occupied.[4] There is really nothing to justify tribal or communal tenure being termed a "tenure of barbarism," as Mr. John X. Merriman declares it is.[5] Intrinsically it is no more "barbaric" or "barbarous" than the "common pasture" of manorial demesne land known to the old Saxon and Norman tenures,[6] or the land of the Teutonic "mark" held in absolute ownership by the village community as common forest or pasture; a tenure which the Bantu tribal law greatly resembles.[7]

On the South-east coast garden vegetables, sub-tropical fruits, sugar-cane, tea, coffee, and lucerne can allow of close settlement. In Natal and in the Transkei, where the Glen Grey system is

---

[1] O. Thomas, op. cit. p. 17.

[2] Wheat grown in the Malmesbury District, Conquered Territory and Basutoland.

[3] Sir W. Beaumont, Union Government, 25-16, par. 36, p. 5. Theal, "Hist. Ethnog," S.A.T., 151. Kidd, "Kaffir Socialism," p. 37.

[4] Evidence of Captain Blyth, Major Elliot, Hon. C. Brownlee, App. C, Report of Commission on Native Laws and Customs, G. 4-83, pp. C 47, 54, 65.

[5] Right Hon. J. X. Merriman, Hansard, 1913, col. 2444.

[6] Stephen's Commentaries, Part I., chap. 22.

[7] "Certain Resemblances of Land Tenure," Rev.: Coloniale and Internationale, II. (1887), pp. 70-87.

largely introduced, the soil is adapted to intensive culture and dairy-farming. The system of small holdings on individual tenure, giving greater security than the mere right of usufruct of native law, has been found practicable, and, says Mr. Sauer, "long experience has demonstrated its advantages."[1] On the other hand, to quote again from Sir W. Beaumont, "experience has (also) shown that it is not desirable to force individual tenure on natives who are not sufficiently advanced to appreciate it, and who are not willing to accept it."[2] Here a study of tribal character and proclivities is requisite and a careful distinction made between Kaffir, Fingo, and Zulu.

The fostering of closer settlement of grantees holding individual title is a course very suitable to the circumstances of the Transkei and Natal, especially if the minor chief or headman of the village is carefully appointed and controlled—"of the blood-royal," if possible. As Mr. Thomas says, "the archaic Kaffir is the best all-round cultivator of South Africa,"[3] and has a future before him as "peasant proprietor." But the wisdom of extending the system to the Bechuana of the plains, and the Basuto of the mountains seems questionable. Let them adhere to their tribal communal tenure.

Whatever system our anxious rulers intend to adopt with regard to the native they must accept the fact that his aptitudes are mainly pastoral or cultural. A few Bechuana or Thonga clans may effect a trade with their rude manufactures; a few Fingos may as usurers and achieve the financial ruin of their hereditary foes, the Gcalekas; but the large majority of the Bantu race cling to the soil, adscripti glebae.

In industries and manufactures the native cannot compete with the European except by receiving a wage lowered to the detriment of the white man, whose superior skill has to satisfy a higher standard of comfort. Where competition exists it may be suspected that "Gilbart's Law" with regard to currency obtains here with regard to labour. The inferior article drives out the superior. We see this when the Bantu press into the cities and mines, just as in the case of the Chinese or Indian: only with the Oriental the disparity in intelligence is not so great. "You must counteract," said Mr. W. P. Schreiner, "this most dangerous tendency on the part of the native to get away from agricultural life. He becomes spoilt by high wages in mines and towns, and often dissipates the money and gets away from his environment of life and becomes a waster."[4]

The Government is probably acting wisely in extending gradually the system of local self-government instituted by the

[1] Hon. J. W. Sauer, Hansard, 1913, col. 2542.

[2] Sir W. Beaumont, "Minute to Minister of Native Affairs," Union Government, 25-16, par. 48 (p. 7.).

[3] O. Thomas, "Agricultural and Pastoral Prospects of South Africa," pp. 15-17. On the other hand Dudley Kidd says, "The native is merely the worst cultivator of soil in the world."

[4] W. P. Schreiner, Evidence before Native Land Commission, Union Government, 19-16, Vol. II.

Glen Grey Act of 1894. But the "bunga" is too advanced in its aims and constitution for its "rude and redeless" members, who are not even representative, but the nominees of nominees. It might conceivably prove more useful, and develop more naturally under the presidency of a hereditary chief holding his power as the executive ruler or regent on good behaviour under European control. This system is in vogue in Java.

The native artisan, trader, and "physician" mentioned by General Botha in his speech introducing the Native Land Act Amendment Bill in March, 1917, will not hold their own against Europeans, and could only be employed in the lower walks of journeyman, shopman and herbalist. They would be better engaged in the native locations and villages than endeavouring to earn an independent living among white men in the towns.

As for the educated native whose ambitions and abilities have enabled him to qualify in the higher branches of employment, such as the church, the law, the Senate, let him preach to native congregations, practise in the native law-courts, and "raise the level of debate" in the general council—"talk" being recognised universally as the unfailing panacea.[1] Better still, let them aspire to the position of induna or councillor who in olden days were selected from old men of tried sagacity or strong character and influence gained by wealth or wisdom. "Go to the native areas," advises Mr. Sauer, "and become leaders of the natives." "Stay with your own people," says the American negro of Tuskage, "to lead them along the paths of progress which are most natural for them."[2]

[1] Report of Chief Magistrate A. H. Stanford. Blue Book Native Affairs, 1908, G. 19-1909.

[2] T. Schreiner, Hansard, 1913, col. 2466.

THE HEAVENLY BODIES IN SOUTH AFRICAN MYTHOLOGY.

BY

REV. S. S. DORNAN, M.A.

Read July 13, 1921.

The present paper deals with the sun, moon, and stars in native folklore. Apparently there is no very clear distinction drawn between the sun and moon, at any rate in Bushman folk tales. Each is as important as the other. They are generally regarded as living things, that can influence the destinies of the people, and even imprint their shapes upon them.

THE ASTRONOMICAL LORE OF THE BUSHMEN.

It is an open question whether the Bushmen actually worship the heavenly bodies. Dr. Bleek says that "the Bushmen are clearly to be included amongst the nations who have attained to sidereal worship."* He says the sun and moon are prayed to, and quotes two prayers to each in support of his statement. While I am disposed, on the whole, to agree with Dr. Bleek, it is difficult to say how far the Bushmen of to-day really worship the sun and moon. I have little acquaintance with the southern Bushmen, and that almost wholly derived from books, but from what I know of the Tati and Ngami Bushmen I should hesitate to apply the term worship to them. That they reverence the heavenly bodies, more especially the sun and moon, is true, but they seem to have more fear of them than anything else. They think that they must keep on good terms with them if they are to be successful in hunting and love making. Several of them, whom I questioned, denied that they worshipped the sun and moon in the sense that the Bechuanas worshipped God. I did not attach much importance to their denials, however.

Amongst the Bushmen the sun is regarded as a man from whose armpit brightness proceeded. He lived formerly upon earth, but his light only extended round his own house. As this was not satisfactory some children were sent to throw him into the sky while he slept, since when he shines over the earth. When the children took him up he felt hot, and they threw him very gently into the sky without wakening him. In the same story the moon is made by the sun in the following manner:—A man incurs the wrath of the sun, who pierces him with his knife, and goes on cutting him away until very little is left, and the moon implores the sun to spare even his backbone for his children. From this cutting process the moon grows until it becomes full, when the work begins all over again. This is to explain the waxing and waning of the moon. I once asked some Tati Bushmen why the

* Bleek, "A Brief Account of Bushman Folklore," p. 9.

sun did not wax and wane like the moon, and the answer was that the moon was the child of the sun, who could do with it whatever he liked. In another tale a different origin for the moon is given. The mantis is overtaken with darkness on its way home, and throws its shoe into the sky, ordering it to become the moon. The shape of the gibbous moon may have suggested this explanation.

The moon also figures prominently in the stories relating to the origin of death. The Bushman story is somewhat different from both Hottentot and Bantu. The latter are very much alike, the Bantu story being manifestly borrowed from the Hottentot. In the Bushman tale the hare is lying dead, and the moon strikes the young hare with its fist in the mouth, telling it to cry loudly as its mother is quite dead and will never return to life again, as the moon herself does. Hence owing to the moon's blow, the hare has a cleft lip. There are several variations of this story. In some of them the moon is angry if people laugh at it, and thus hides itself, or disappears for a time, but it always revives.

The Bushmen seem to have paid more attention to the moon than to the sun. Their dances always took place at full moon, and were generally kept up all night, or until the performers could no longer continue through sheer exhaustion. Sometimes they began their dances with the new moon, and continued them till the full moon. The appearance of the new moon was an occasion of rejoicing, and much reverence was undoubtedly paid to her. Prayers were often sung to the new moon, of which Dr. Bleek* gives examples, but they all refer to hunting or making provision for bodily sustenance, of which the Bushmen often had experience when drought or a spell of bad weather prevailed and game was wild and scarce.

The origin of the stars is thus explained by the Bushmen. A girl who wanted some light for the people to return home when it was dark threw a handful of wood ashes into the sky, and they became the Milky Way, but having had a quarrel with her mother who had given her too much food she threw portions of it into the sky, and they became the stars. There are some other variant accounts of the origin of the stars. Most of the more conspicuous stars and planets had names. These were usually animals, but some of them had been men in a former state of existence, such as the two pointers of the Southern Cross. These afterwards became lions, and certain other stars of the same constellation became lionesses, and long and elaborate myths explain how this came about. Amongst the Tati Bushmen the Southern Cross is the giraffe star, the two pointers being the head and neck of the animal standing in a certain position. Other stars such as Aldebaran, Procyon, and Orion's Sword are called the male hartebeeste, the male eland, and the male tortoises, while Orion's Belt is called the female tortoises. Amongst the Tati Bushmen similar designations are applied to them, and many of the same tales are current also.

* Bleek and Lloyd, "Bushman Folklore," p. 415.

The rising and setting of particular stars was noted by the Bushmen, especially at certain seasons of the year, such as the beginning of summer, or the rainy season. On the whole it would appear that the heavenly bodies figured largely in Bushman mythology and religious custom, but whether they actually worshipped these in the sense that Dr. Bleek implies is doubtful. We want to know more definitely what meaning to attach to the term worship. That they looked upon the sun and moon as mysterious beings with some influence over their lives is true, but is this worship? The Bushmen were not highly enough organised to have a regular system of worship and priests to attend to it. The beginning of sidereal worship may be traced amongst them, but it had not gone so far as to become a regular cult.

The Astronomical Lore of the Hottentots.

Whatever may be said regarding the Bushmen, amongst the Hottentots moon worship was a recognised cult, a regular part of their religious life. Kolben, who was at the Cape from 1704 to 1713, and who gives the earliest and most exhaustive account of the Hottentots, leaves no room for doubt on this point. Quoting Boeving, he says:—

> " 'Tis well known there is a common opinion received among travellers living among and in the neighbourhood of the Hottentots that these people adore the moon, and that they celebrate her worship with acclamations, invocations and dancings whole nights in the open fields."
>
> "And so they are, let the Hottentot say what they may. These dances are religious honours, and invocations to the moon. They call her Gounja. The Supreme Being they call Gounja Gounja, or Gounja Ticquoa, the God of Gods, and place him far above the moon. The moon with them is an inferior visible God, the subject and representative of the high and invisible. They judge the moon to have the disposal of the weather, and invoke her for such as they want. They assemble for the celebration of her worship at full and change constantly. No inclemency of the weather prevents 'em."* He goes on to say that "their behaviour at such times is very astonishing, throwing ther bodies into different distortions, shouting, stamping, screaming and uttering strange and unintelligible expressions."

He gives some specimens of their addresses to the moon, such as "Mutschiatze," i.e., "I salute you"; "Chera qua ka ha chori Ounqua," i.e., "Grant us fodder for our cattle and milk in abundance." These words are repeated over and over again, and in these and other similar expressions with accompaniments of shouting, screaming, singing, and stamping, lie all their formalities in the worship of the moon.

> "The fervours of their devotion are unequall'd, and when they have done they retire to their homes with as much cheerfulness and satisfaction as do any other people in the world from the performance of their religious duties."

It is fairly obvious from this that they reverenced the moon in a very high degree. Hahn in his "Tsuni//Goam, the Supreme Being

* Kolben: "The Present State of the Cape of Good Hope." Vol. I, pp. 95, 96, 98.

of the Khoi-Khoi,'' quotes corroborative testimony from other old travellers, from which it would appear that //Khab, the Moon, and !Khub the Lord are not clearly distinguished in Hottentot mythology.*

The following tale, common also among other nations than the Hottentots, in various forms explains how death came into the world. The moon on one occasion sent the chameleon with this message to men: "Oh men, as I die and am renewed again, so you will die, and be renewed again." Now the chameleon was a slow fellow, and as he went he forgot the message, so he turned back again to get it correctly. The moon was angry and called the hare and said to her, "You are a quick runner. Take this message to men: "Oh, men, as I die and am renewed again, so you will die and be renewed." Away ran the hare, and on the journey forgot the message, and delivered it in this form: "Oh, men, as I die and am not renewed so you will die for ever." When the hare returned the moon questioned her as to the form of the message she had delivered, and when she heard the manner in which it had been delivered, seized a stick and struck the hare in the mouth, splitting her lip, and so every hare has a cleft lip to this day, and that is how death came into the world. In some variants of the story it is one of the men, to whom the message is delivered, who lifts a stone and strikes the hare in the mouth, splitting her lip. There are many different forms of this story, but the central idea in all of them is the same. Here the moon is evidently some kind of Lord of Creation or minor divinity. There are other tales in which the moon figures prominently also. The sun does not appear to have such power over the lives and fortunes of men as the moon. He seems rather malevolent in some conceptions of his relation to man and the animals. The origin of the jackal's stripe is explained thus. Some men on a journey saw the sun sitting by the wayside, but took no notice of him. A jackal who was following up the men saw him sitting, and going up to him said, "What a nice little boy the men have left behind." He then took the sun up and put him on his back, but by and bye the sun began to burn him, and he ordered him to get down. The sun stuck faster, with the result that he burnt the jackal's back black to this day. The sun sometimes uses other animals such as the horse and the ox. The former when he catches him to ride on cannot bear his weight, so he curses the horse, who had previously been immortal, with death. The ox does much better, and bears the sun's weight quite easily besides being good tempered. As the Hottentots used riding oxen it was quite natural for them to exalt the ox above the horse or quagga. They never succeeded in domesticating the zebra or quagga that abounded in their country, though from this tale it would appear as if the attempt had been made. According to Sparrman and other travellers the quagga was comparatively good tempered. The quagga and zebra were probably no wilder or more intractable than the herds of wild horses that

* Th. Hahn. "Tsuni // Goam," p. 39.

primitive man domesticated. It thus appears that the moon in Hottentot mythology was a beneficent being, and had the gift of the good things of life in her hand. Thus worship was paid to her.

There is not much in Hottentot mythology or folklore regarding the stars. Certain of them had distinctive names, but beyond this practically no tales connect them with man, except such as are derived from the Bushmen. The rising and setting of particular stars that heralded the advent of the seasons was noted, but no special honours were paid to them.

Astronomical Lore of the Bantu.

Amongst the Bantu sidereal worship is practically non-existent, ancestor worship takes its place. As these people are still more civilised than either Bushmen or Hottentots it might have been expected that the worship of the heavenly bodies would have been further developed. This may be explained by the fact that their origin has been different from the former. There is a Bechuana tribe practically extinct now, or at least absorbed in that tribe, who are called the Ba-letsatsi, or men of the sun. The siboko or tribal emblem is the sun. Stow gives some curious information regarding them which I have not been able to check in all particulars. He says:—

"The Ba-letsatsi, or men of the sun, when the brilliant star of day rises in a cloudy heaven, do not work, saying that it afflicts their heart. The food prepared the night before is all given to the matrons, or aged women, who alone may touch it, and who give part to the children under their care. On such mornings these people go down in a crowd to the river, there to wash their whole body. Everyone casts to the bottom of the water a stone which they have carried from their hut, and which is replaced by another taken from the bed of the river. On their return to the town after their ablution, the chief kindles a fire at his house, and all his subjects go to get fire from it. This, therefore, represented a consecrated or sacred fire, that is the sun from which all receive their warmth. After this ceremony, begins a general dance in a public place. He who has lost his father raises his left hand towards heaven; on the contrary, he who has lost his mother raises his right; while the orphan, who has lost both, raises neither, but crosses both his hands upon his breast.

"This dance is accompanied by a monotonous song, when everyone says:—

'Pina ea Morimo, u ee gae
Ki lema Ka lefe
U ee gae! U ee gae.' "*

which the author translates as follows:—

Song of the Shades of the Departed (Morimo) go home!
Which is it that I raise (i.e., which hand)?
Go home! Go home!

The translation is not very apt. Morimo is not the Shades of the Departed, but the usual word for God. Moreover, the dance here referred to, with its accompanying song, is not peculiar to the Baletsatsi, but is performed by other clans of the Bechuana tribe with slight modifications, and the same remark applies to the song.

* Stow, "The Native Races of South Africa," pp. 414-5.

Rev. John H. Weeks, in describing the Congo peoples, states that the view is held among the primitive Bakango peoples that the sun is a place of punishment for bad spirits, and that the moon is supposed to be the place where the good spirits converse with one another. After death they say there is a branching of the roads, one leading to the sun and the other to the moon. The spirits of bad folk always take the former, and that those of the good take the latter road. When there is a halo round the sun, they point to it as a proof that a "judgment court" is being held there, and the punishment allotted to the bad is being confirmed by the Supreme Being, and should this halo appear about the time of a death the relatives of the deceased will wail long and loudly because their departed one has gone to be punished. The shooting stars are believed to be spirits travelling or playing about in the sky, and anyone seeing them will rush into his house from fear of one of them falling on and entering him. Mothers will not allow their children to remain out of the house when there are shooting stars about, lest one of them should enter her child.*

There is nothing closely corresponding to this in Bantu mythology that I can discover. There is no notion of heaven and hell of this sort amongst the Bantu peoples. Certain dances of a religious character take place at full moon that may be connected with her worship. Any of the tribes from which I endeavoured to obtain information said there was no particular connection, and resented the suggestion of moon worship. At the changes of the moon certain particular dances were held, but what part they had in moon worship I cannot say. The moon must have played some part in primitive Bantu religion, or a most peculiar tale, current amongst the Basuto, would not have come down to us. The tale is called "The Child with the Moon on his Breast," and bears a most extraordinary resemblance to one given by Day in his "Folk Tales of Bengal," with much the same title. The Basuto tale may be found in Jacottet's "Treasury of Basuto Lore," Part I., p. 190. When I first heard this story amongst the Basuto I paid little attention to it, beyond thinking it was very curious. My astonishment and interest were great when I found an almost exact parallel to it in Day's collection. The following is an outline of the story:—There was once a chief called Bulane who had a moon on his breast. He had two wives. One had children, the other had none, and was spitefully used by the one who had children. After a time the childless woman gave birth to a boy with the moon on his breast. The other woman, who was acting as midwife, took the child and threw him away among the pots in the back of the hut, and then she went out and got a little dog and placed it beside the mother. She had fainted in the interval, and when she came round the other woman said to her, "Look, you have given birth to a dog." The sick woman was very sorry. Bulane was then told that his wife had given birth to a dog, and he was very angry, and ordered it to be destroyed. Some time after the other wife went into that hut and found a mouse playing

* J. H. Weeks, "Among the Primitive Bakongo," pp. 279-281.

with a child with a moon on its breast. She was terribly frightened as she thought the child was dead. The mouse had, however, taken him into its hole and nursed him. Immediately she persuaded her husband to burn down the hut, as to go into it always made her ill. He wondered at the request, but consented, and the hut was burnt. The mouse heard the conversation, and determined to save the child, so he took him to the wall of the cattle kraal before the hut was burnt down. A long time afterwards the same wife went to the cattle kraal, and found the child with the moon on his breast sitting under a cow. She was again very frightened and alarmed, and immediately informed her husband that she had been very ill in the kraal, and that he must pull it down at once. Again the mouse removed the child, and took him to some traders for safety. By this time the boy was nearly grown up, so the mouse left him and returned to its hole. Some time afterwards a man came from the chief's village to the traders and saw the young man. He went back and told the chief what he had seen. Bulane was very interested and went himself. He asked the youth how he came to be there. The young man told him the story of his birth, of the substitution of the dog, and how the mouse had saved him, and had brought him up. Bulane was convinced when he saw the moon on the youth's breast that he was his own son, so he took him home and hid him in his hut. He called a meeting of his people, killed many oxen, and brewed much beer. During the feast he brought out the youth, and explained to the people the story of his birth and the treachery of his other wife. The mother of the young man was beside herself with delight, and received beautiful clothes from her husband, but as for the other wife and her children she was sent away to her own people, as they said she was a wicked person.

The Bengali tale has much more mythological drapery about it, but in all essentials it is the same. What is the explanation of the extraordinary resemblance? It cannot be conscious borrowing, as the Basuto have had no intercourse with any natives from India to such a degree as to account for this. Is it part of the deposit of primitive lore, which was common to the ancestors of Basuto and Bengali. This is a very great assumption to make, and is not warranted by our present knowledge. The parallelism of the two tales, though interesting of itself, does not prove the descent of Basuto from Bengali, as has been attempted in a recent book on negro religion.

The South African Bantu pay little attention to the stars. They have names for certain prominent stars, but they do not pay them divine honours. It has been remarked how little notice they take of the constellations. The Bantu have never troubled themselves about astronomical calculations in the past, so far as we can discover, any more than they do now.

Amongst the Bushmen we find sidereal worship in its inception, amongst the Hottentot much more developed, and amongst the Bantu hardly at all, far less so than one would have expected, taking their superior culture into account. Has the supposed

origin of the Hottentots anything to do with their worship of the moon? It has been held that the Hottentots are of mixed Hamitic and Bushman descent, and originated in the following manner:—Some Egyptian or Sudanese Hamites fled up the Nile to Abyssinia or Somaliland, and took Bushman wives. In this manner the racial and linguistic affinities of the Hottentots are explained. It is presumed that amongst these fugitives there would be some priests familiar with moon worship, for we must remember that in the earliest periods of Egyptian culture the heavens had been mapped out and names given to the various celestial bodies, and even maps made of the stars. It must be admitted, however, that star worship is rarely alluded to on the monuments, although the Dog Star was the soul of Isis, and Orion the soul of Horus.* I doubt very much if there is any connection between the Hottentots and the Hamites or Egyptians in the manner thus suggested.

In the April issue of the "Geographical Journal" for 1921 there is a review of a German publication on East Africa by Sir H. H. Johnston, in which he says:—"The Iraku, Fiomi, Wasi, and perhaps the Mbulunge tribes, who are distantly allied to the Hamites in speech and partly so in physique (that is to say related to the Galla and Somali); and lastly, the Sandawi and Kindiga, whose languages abound in clicks and offer a slight resemblance in word-roots to Hottentot, and in phonology to Bushman."† I do not know his authority for this statement, but in any case it is most interesting. It confirms what my own researches amongst the Bushman tongues have led me to, that the Bushmen and Hottentots are ethnologically and linguistically one people, but the separation took place so long ago that they are now at any rate in language quite distinct. I look upon the Hottentots as more civilised Bushmen, and their language further advanced in development, due to their greater civilisation. Johnston in the same article further says:—"Here seemingly we have the birthplace of the Hottentot race, and perhaps a former home of the Bushmen and Strandloopers. There are traces of the Congo Pygmy embedded in such tribes as the Kindiga, who are living under the most primitive conditions, without agriculture or domestic animals, and, until recently, without clothing." This throws much light on the origin and migrations of both Bushmen and Hottentots. The star worship of both peoples would simply be part of their original religious beliefs, which they brought with them when they were driven out of their ancestral home, probably by invasions of Bantu or Hamites. It would seem to prove that their worship of the heavenly bodies was indigenous and not borrowed.

* Erman, "Life in Ancient Egypt," p. 349.
† Johnston, "The Geographical Journal," April, 1921, p. 286.

THE BANTU IDIOMATIST IN THE FIELD OF COMPARATIVE PHILOLOGY.

BY

REV. PROF. W. A. NORTON, M.A., B.Litt.,

University of Capetown.

Read July 13, 1921.

The study of Bantu philology is still so much in its infancy that very few realise its immensely wide scope, its various divisions, its manifold difficulties, its large tracts of uncertainty, and yet its enormous importance to a galaxy of sciences and great practical value in our ever pressing problem.

A man who attempts to cover the whole field of the family, as Sir Harry Johnston, with undaunted courage, has done in his vocabulary of some 300 Bantu languages, is often little spared by the critic who has, or thinks he has, a good knowledge of one dialect. But, on the other hand, the authority on a single language is apt to get very bad falls when he ventures himself into the wider sphere of comparative philology.

A rather startling instance of this is seen in a distinguished Zulu scholar (Rev. A. T. Bryant), who gives lists for comparison of Zulu with Sanskrit, Arabic, Malay, and Papuan respectively. It is true that in the last case he "would not like to aver, at the present moment, that (the resemblance) is anything more than chance," and here we will therefore omit to comment.

Of the Malay words he suggests for comparison:—

djabat with tabata,	lapar with lamba,
dankan ,, tenga,	ikan ,, intlanzi,

these might be (conceivably) worth the trouble of such comparison, and *ma-bap* tends to appear for *mother* and *father* all the world over, but *imvula* and *hudjan*, *tshala* and *lamun* puzzle one as to why they are recorded.

Now to take the Zulu-Arabic list ("not of course definitely related," says our author, "but which may provide the comparative philologist with a little concentrated matter for study"—as therefore conceivably related): one of the Zulu words given, *imali*, is recognised by so reliable a scholar as Meinhof as being not cognate with, but actually borrowed from, not the English *money* as some Zuluists supposed, but the Arabic *mal*, property, which appears also in Swahili.

Kohlela, *Kahh* and our "cough" may be imitative, and *bomvu* (red) may be conceivably related to the Arabic *bamba; ntsundu* to *sudd* (black), *kuluma* to *kellim*, and *inkomo* to *gamus* and *gamal*—I say conceivably, meaning no adhesion to the view. In other cases, the Zuluist gives two Arabic forms, sufficiently distinct to show at once the more than problematic nature of any possible connection, e.g.:—

ingubo	with	gukh and hudum,
umhlabati	,,	ard and tin,
ambata	,,	ghata and bavad,
hamba	,,	hadjdja and ghab.

But what shall we say of *inyama* and *lahm*, *isikati* and *waqt*, remembering the vagueness of the usually unwritten vowel in Semitic,

utshani	and	hashish,	ulwandhle	and	bahr,
umhlobo	,,	hahib,	indhlovu	,,	fil,
umtombo	,,	bir,	idwala	,,	hagar?
bala	,,	manah,			

Was it worth the printing to record these pairs, which often have but one consonant, and sometimes but one letter in common?

NOTE.—It is true that Suto *lentsoe* (word) is connected with Zulu *ilizwi*, and both with Suto *utloa*, to hear, Peli *kwa*; but here Meinhof's (*iju*)*ngwa* and its noun explains the variation. No such explanations are suggested by our Zuluist.

That our authority thought it worth while, labour and expense, is shown by this, that he often spends many lines of his page in the dictionary in inserting this philologically useless material.

Remember, please, that I am sneering at no one, least of all at real idiomatic authorities, who have the courage to undertake and the vigour to complete that heroic drudgery of lexicography in any language. I am merely pointing out that true Bantu study is so serious a matter that no one could expect the idiomatist to be authoritative on comparative philology, any more than we could expect the philologist to profess all, or (necessarily) any of the Bantu tongues, for neither do we expect the Aryan philologist to be a special authority on Welsh or Armenian.

But to come to the comparison of Zulu with Aryan suggested by our Zuluist, I will abstract a few of his pairs (Zulu-Sanskrit), placing the original Bantu, where known, to the left of the Zulu and the original Aryan to the right of the Sanskrit. Where the means would suggest to the normal philologist any possible connection I place a query, otherwise a comparison of the extremes will at once explode any hope that connection may be established, any slight resemblance in the means usually disappearing in the original forms.

(N.B.—I use ij for the Hollander g, after the *Anthropos* system. This symbol should appear as y with two dots.)

Bantu.	*Zulu.*	*Sanskrit.*	*Aryan.*
inkuku	inkuku?	kukhuta	(this may be a case of borrowing via Persia and Egypt)
	haha	ghas (eat)	ghesa
	hamba	gam	gweme (come)
kulu	kulu	uru	ewereu (broad)
pa	pa	da	da (give)
kia	sa (dawn)	ushas	awese (lighten)
	sha (burn)	dah	dheghwe

ijîk'o	iso (eye)	akshe	okwe
tanda	tanda (love)	van	wena (wish)
ijia	ya (go)	ya	ei
ijungwa	zwa (hear)	ghra	
		swar (sound)	
		and jiva (live)	gwejew
bamba	bamba (hold)		
	bopa	bandh (bind)	bhenedh
	banda (split)	bha(n)	bhage
	idhlozi (spirit of dead)	dyaus (sky)	dejewo
	dontsa (draw)	duh	dheughe
	funga (swear)	yu (yoke)	jenge
imbwa	inja (dog)	svan	swena (sound)
ink'onî	intloni (shame)	hri	ghreja
amaijiijî	amanzi (water)	udan	ewod

I feel inclined to claim that *intloni* (shame) is related to the French word, and to cry (in the Garter Motto) "*Honi* soit qui mal y pense"! It would look much more likely than the real derivation and certainly than the connection with *ghreja*, which our Zuluist suggests.

I think I have said enough to show that comparative philology is one thing, as applied to the Bantu sphere, and expert knowledge of an individual language quite another. When the possessor of the latter—Bull of the kraal in his own land—attempts the former, he is apt to become the Bull in the china shop.

Do I then say that he should avoid any interests in comparative philology? The gods forbid. Let him make himself as cognisant of the comparative side as he may, for without such knowledge his special work in his own idiom will be far less expert and valuable. I blame not him at all, but blame the widespread ignorance which allows not only the public, but even academic authorities, to expect that Bantu philologists shall be expert in 300 idioms or the deep lifelong student of Zulu or Sesuto to be a comparative philologist.

To each his own work according to his gift: *Ne ultra crepidam*. May I ask that our Zuluist will apply to my erring incursions into Zulu (infrequent enough) his own precious balms in like merry spirit? Would that I had his experience and learning in the Zulu and matters Zulu.

ADDENDUM.—Miss Werner passes *waqt* (Arabic) as the origin of the Zulu *isikati* (and Swahili *wakati*). Is *iahm* after all connected with the Zulu? But surely not the others.

SESUTO PRAISES OF THE CHIEFS.

BY

Rev. Prof. W. A. Norton, M.A., B.Litt.

University of Cape Town.

Read July 13, 1921.

Like the bards of Homeric times, or, if you prefer to come nearer home, of Ossian's times, or to go further afield, of the South Sea Islands, the Samoa of Robert Louis Stevenson—for the afflatus knows no limits of time and place—the praisers of the Native Chiefs have been very busy pouring forth enconiums of greater or lesser length and value. These, but for the neglect of the younger generation, might have blossomed into sagas of Native make and, with the arrival of the constructive poet, into epic.

As it is, the old men—who are repositories of the lore—are dying day by day, but the " Leselinyana Magazine " and other publications of Morija have done good work in preserving much. On coming to Natal, I always read the native novelist, Mofolo's charming odyssey, "Moeti oa Bochabela" (The Pilgrim to the East) which, with a little more bloodshed, might have been saga or, in verse, an embryo epic. But most of the work of preservation is done by Europeans. "Golden Glory" and Mr. Haigh's "Ethiopian Saga" follow Sir Rider Haggard with a more native viewpoint. We are glad to know, however, that at Lovedale prizes are being offered for native collections. I have been using the schools I visit for some time in this way, and have made efforts to get some endowment for the purpose—so far in vain.

But the old men are dying, and the younger generation, if it starts with zeal to-day, will have to put forth some effort to overtake their death-rate; and the work is by no means easy, even for a native. The dialect is very special, and most extended explanation is required. Every line is crammed with associations like those of a Greek chorus, associations often lost in the mist of antiquity, and the informant is often in the last stage of decrepitude, blind and deaf. At the point of wildest excitement, or most trying intricacy, he will hobble off tired, and adjourn till to-morrow. You go on the morrow, and, in spite of his decrepitude, he is away on the lands: you cannot stay, and the opportunity is lost, perhaps for ever.

Some of the Sesuto praises of the Chiefs may now be cited, together with their English translations.

I.

TSA MOSHOESHOE.

[Ke] Mahahanyana oa Ratikoane,
litelu mmele oa R.:
lijo li yeoa ka ho mela litelu.
Ke phiri ea habo Makheme,
ke Mahlo-mahahanyana oa Ratikoane:
ke ntho ea hae; ha a okeloe hae,
o okeloa lithabeng.
Ke ratilitili oa meropa Mangesimane,
ke liphaka tse maroba
mohla ntoa ea morena Lerotholi le Maama.

Praises of Moshesh and His House.

I am M. (the eruption) of Ratikoane,
Of Ratikoane's hairy body:
Food is eaten by growing a beard.
I am the hyena of Makheme's men,
The protruding eyes of Ratikoane.
I am a thing of home; he is not nursed at home,
But on the mountain.
I am the throbbing of the English drums,
I am the wound scars
In the time of Lerothodi's and Maama's war.

II.

TSA TSEKO NTSANE.

Petha lebotha la Maphiri:
[Sechichachichane] ke thaka Ramonella (?).
Ntsane, o se ke oa feta Moshoeshoe:
Moshoeshoe ke khomo, re anya lebese.
Seripanye sa 'Ma-Leshoboro
a bona motho, ka tholo a mo putla.
Pele ho lioli ha tuka khabo,
ha tuka le lelakabe le kopane le loto.

Thak'a Masenkane, o un' o romela,
o romele ho Setho le ho Sofonia:
o re, Khoanyana leo le le bonang moo,
le ee le le ts'oare
ke be ke fihle, nna thal'a-maliboho
oa bo Ntsane le Sekhonyana.
Le pota thaba, le bosiu,
Lekhikha la haboNthakhi le Malefane
le tsoile ka la haTaoana lekhalo
le teng le ts'aba morena Letsie.

Of Tseko Ntsane, Moshesh's Grandson.

Complete the Regiment of the Hyenas:
The tiny hornless ox is the mate of Ramonehela.
Ntsane, do not go beyond Moshesh:
Moshesh is a cow: we get the milk.
The defender of Leshoboro's* mother (Matete)
Saw a man with a club (? gunstock), he hit him;
Before the owl regiment there blazed a flame,
A blaze mingled with lead. (War of Sequiti, 1865-7).

Mate of Masenkane, you must send—
Send to Setho and Sofonia (Ntsane's brothers):
Say: "That little white man who you see there—
You must go and hold him till I come,—
I, the old man (Umdala, Xosa) of the drifts
Of Ntsane's and Sekhonyana's folk."
He† goes about the mountain, even at night,
The runner of Nthakhi's and Malefane's people:
He has gone out by Taoana's pass—
Even there he fears the chief Letsie.

* Leshoboro was the son of Mayara and Matete: Mayara and Ntsane (father of Tseko) were two of Moshesh's sons. Ramaneela or Lesuoana was son of Moshesh's brother Makhabane.
† Probably Ntsane: Sekhonyana is Nehemiah, son of Moshesh.

III.

TSA MOTHEBESOANE.

U Thebe, Lents'a, u thebe:
U tyeke, u thebe-nalana
ea ho hlomella mokhele.

Of Mothebesoane, Uncle of Moshesh.

You are a shield, Lents'a, a shield:
Dance: you are a white and red shield (of cowskin),
Supporting the chief's banner.
(Really a tufa, like S. Edwin's, in Bede.)

IV.

TSA JONATHANE.

Sekoakoabela-sa-linare-talla
oa boMaria, mor 'a Mamosa-kharapana,
molalla-Mokapana le Mahetlana,

tsoeu-talla ea haboMphaphathi.*
Ha a e'tla metsi h'a salla liesola
ho setse boHatane le Kolojane.
Ngoan'a MaMosa, ha u sa le talla, u hlohlometse.

Ts'oeuyane sekubutu ha Neheng,
koena mots'esi oa Tholoana-leqhaoe,
mor'a MaMosa, maTimapane, MohatlaRapolo,
ha u sa le talla, u hlohlometse.

Ngoan'a ntloana a robetse a lore,
a lore a khaola nare hloho,
Mopota-nare ke Lepota-leZulu
Sekoakoabela sa linare-talla,
ha o sa le talla, o hlohlometse.

OF CHIEF JONATHAN, GRANDSON OF MOSHESH.

Swaying goer of the wild oxen (regiment) ambushed,
Of Maria's* men, son of 'Mamosa of the stony hill,
(See note at end)
Lier-in-wait for Mokapana and Mahetlana (the Cucumber and Hunchback),
The light-hued ambusher of the men of Mphaphathi.*
When he comes, the waters do not wait for the weak;
There wait the men of Hatane and Kolojane.
Son of 'Mamosa, if you are still in ambush, you are alert.
A fair-skinned overwhelmer at Neheng's,
The crocodile, the swimmer of Tholoana-leqhaoe (chief wife),
Son of 'Mamosa, Matimapane, the tail of Rapolo,
(circumcision name)
If you are still in ambush, you are alert.

While the child of the little house† sleeps and dreams,
Dreams that he cuts off the wild ox's head,
He who gets round the wild ox can get round the Zulu (or the sky),
Swaying goer of the wild oxen (regiment) ambushed,
Though you are still in ambush, you are alert.

* Jonathan's sister.
† His brother and rival Joel, son of an inferior wife.

V.

TSELE.

Apara kobo ka lesoba, Mosia,
ikaparele sekhetjana sa lipoli;
hoja ke sa khomo,
Se ka be s'o ts'anna (ts'oanela ?).

Of Tsele.

Put on your tattered cloak, Mosia,
Clothe yourself with your scraps of goatskin;
Were it of a cowskin,
It would become you.

VI.
MOFOKENG, MAKOA.

Tlemelele, MaMakoa a Matsitsi!
o hlaba ka koebe, o bone[h]o mang?
Le bone[h]o Letsela le Ntsenki.
Linalanyane tsa mor' a Mokotsoana
tse reng o ts'oara khomo, li e ngaparele,
Mong a khomo ebe h'a[e] sa e bone [tau].

Praises of a Mofokeng, Makoa.

Ha! Mamakoa of the Matsitsi (? regiment),
You strike with a barbed spear; with whom did you see it?
You saw it with Letsela and Ntsenki.
The little nails of Mokotsoana's son (*i.e*, Makoa),
Which say, when you catch an ox, let them grip it,
That he, perchance, the ox's master, does no longer see it (the ox, or the lion).

VII.
TSA MOLISE.

Ke bohale, ba Ra-ka-litelu,
phatola chicha baRamosinyei,
mohl'a qala mo hapa,
a hapa e phatsoa ea baThepu:
na u fela u re U morena?
Morena ke oa Mokhachane,
haholo ke baNketu oa matlama.

Of Modise, also Mofokeng.

I am the wrath of Rakaditedu,
Cleave the hornless one, men of Ramosinyei (his daughter).
When he begins to reave,
He reaves the dappled one of the Tembus (1835):
Do you verily call yourself a chief?
The chief is Mokhachane's son (*i.e.*, Moshesh),
Yea, the chiefs are the men of Nketu (again Moshesh),
Who is of the Binders (regiment).

VIII.

Of Peter Makhobotloane, Also.

Ke mosehlanyane oa Motsoakhunoane:
ts'ehla, apola, r'o bone mahlong.

I am the little light-skinned son of Motsoakhunoane:
Tawny one (*ie.*, lion), uncover that we may look in your eyes.

IX.

TSA NYAPHISI.

Mor' a Phakoe h'a boleloa ke batho:
Tintinyane Ramesi a thunya,
mosi o thunya koana litlhomoleng,
moritele oa Pali a ret[h]ela koana haRamakhula.
Manqotya le Mantoseng,
ha le hana ho fepa Thipa-ea-setala e ote,
e tle e'n'e tsebo ho poma makhotla a batho,
Potyo-lerumo-le-hlabile-mokhosi,
hlabela u etse mokhosi
a utloe a le joaleng.

Maphuthing Praises of Nyaphisi.

Nyaphisi, son of Phakoe, boast not thyself:
A man is fine when so called by others.
Grass warbler, father of gunsmoke:
Smoke there among the guns (Tlhobolo).
Blusher (?Morutheli) of Padi's line, he blushes there at Ramakhula's.
Manqotya and Mantoseng (wives of Nyaphisi),
If you fail to feed Knife-of-the-Stall (a horse), he gets thin,
[So feed him] that he may still know how to cut through the ranks of men.
'Scape-spear (phochoha)—which-raises-the-alarm,
Raise thou the alarm, while they are at the beer.

X.

TSA PITA.

Marumo a ja li-nonne, Pita oa Nyaphisi,
li nonne li le mafura:
letlaka ntlohele, ke ee hae,
ke e'o bona liotloana hae,
liotloana mots'egare li ba ntle.
Thak'a ngoan'a Ntloi a kalla ts'oene,

h'a re "Ka sa ka kalla ts'oene":
bakoenehi koenehang, e sa le kajeno,
tsela li e-so mele mefero.
Rona ba boMosa, re sa le re loana,
ngoana o tsoile ka phofu-ea-lehlaka.
Pita, o se ke oa leka oa feta Seoehla.
Seoehla ke 'mao le ntat'ao,
S. ke khomo, h'a ka a fetoa.

OF PITA, HIS SON.

The darts eat up the fat one, Pita, son of Nyaphisi,
Even the cattle that are fed fat:
Vulture, leave me, that I may go home,
May go to see the scherms at home,
The scherms which are fair at noontide.
The mate of the child of Ntloi beat a baboon,
When he said, I have just fought a monkey:
Ye rebels, rebel, while it is called to-day,
Ere the way be grass-grown (*i.e.*, barred by enemies).
We, the servants of Mosa (Molapo's daughter), while we still fight,
The child hath gone forth with the Eland of the Reed.* (P.'s son, Hlokoa.)
Pita, try not to pass Seoehla (the chief at the back of the host):
Seoehla is thy mother and thy father,
He is an ox not to be passed.

* The symbol of childbirth.

XI.

TSA LECHESA.

Morena, joale ke ea joang,
ke sa le a its'oara le thebe bolimo,
lithebe a li jara, a li isa Matebeleng.
Lechesa, h'a a (e) ja, ba mo lebala,
ba mo hopola ha ho ts'oeroe lithebe,
Pholo (ha li ea likhomo), mor'a khosi,
ha e'so ho sole, e sa otile;
morena Rampetetsi a makhotla,
makhotla a petetsane sebohong,
Moja-moja-mojang-mosueu,
mohats'a Sebili sa baTaung.

Praises of Batlokwa and of Lechesa.

Chief, how do I go?
I am still one who holds himself with the shield above.
Shields—he bare them, he took them to the Matabele,
Lechesa, when he ate them up, men forgat him:
They remember him when the shields are seized (when they need
him),
The ox (when the cattle go), son of a chief,
Has not yet lost its old hair, it is lean:
Chief Rampetetsi (presser) of the hosts,
The hosts are jammed together at the drift,
Eater up of the white men (or man of the snow-white kilt, Musha),
Spouse of Sebedi of the Bataung (Lechesa's wife).

XII.

TSA KHANYE.

K. a maroala a bots'abelo,
nka bana, u ba ise likhaeng,
a ee lule le bona likhaeng.

Of Khanye, His Father.

Khanye of the Crowned (regiment) of the Refuge,
Take the children and carry them to where they build,
Go and stay with them where they build.

XIII.

LEBAKA.

Lebaka, child (belly) of Musa, dance at Ramotsehare-o-Moholo's
mor'a maMohlahloe,
ke Sekholomi isaisane ea mofuta oa batho,
o ea ba isa a ba balehele.

Of Lebaka.

Lebaka, child (belly) of Musa, dance at Ramotsehare-o-Moholo's
(Father of Midday), son of Mohlahloe (sister of Lebaka).
I am the Speaker, the Bringer (regimental name) of the sort of
men,
He will bring them and run away from them.

XIV.

TSOETETSI.

Tsoetetsi ea maphatsoe, mor'a Lebaka,
sechicha se mahlomaholo,
naleli ea Molatoli ke tsa mang?
li hlapanyetsa Tebele, bahabo ha ba mo hlapanye,
ha ba mo hlapanye,
ha ba ka ba re'Tsoetetsi a maphatso(e),
ha le utloa (a) lumela Mahlatse,
le re, H'a se lumele, a etse joang,
ha e le bafo ba boNtatisi, e le bafo, ba qhats(any)etsoa mofehlo
Sekonyela ke motho oa Molingoane,
o latotsoe ke Molingoane.

Of Tsoetetsi, His Grandfather.

Tsoetetsi of the Maphatsoa (regiment), son of Lebaka,
Skull with the great eyes,
Whose are the stars of Molatodi?
They swear to the Matebele,
His people swear not by him, they swear not by him.
They did not say, "Tsoetetsi of the Maphatsoa."
When you hear they roar applause.
You say, Why should he not agree? What else can he do?
If it is the servants of Ntatisi's folk, servants for whom butter-
milk is poured,
Sekonyela is Modingoane's man,
But he is denied of nim.

XV.

MOTHOANE.

Mothoane: Ke sekolebeta sa RaJosefa,
Sa beta motho ts'imong ea Lebusa.

Of Mothoane.

I am the champion of Josefa's father (Molapo):
He wrestled with a man in the garden of Lebusa (a cousin of
Lechesa).

XVI.

MOKOATHI.

Mokoathi oa makhoatha-holimo,
kh(o)atha tlala e ba bolaee ba haLetijane.

Of Mokoathi, Lechesa's Son.

Mokoathi of the "flickers-up" (regiment ?),
Flick some hunger, that he may slay Letijane's men.

XVII.

MOTINATINA.

Motinatina: Khomo ea lihloela tsa Ramabaleha,
khomo ea Bokone ea Matebeleng,
ea runoa linta le mapokaetsi.
Khomo ea lihloela e sesa moholi,
khomo ea Bokone ea Matebeleng.
Mohaha-hlabana oa bammuso,
mohale a hlabana thunya li boee,
Mohale-oa-liKatrise-tinane,
O ile a hlabana Mathebe, bosiu bo sele,
mohla ho bolaoang Posholi,
RaMathibila litlhomola Letina Ramatsabisa mafora
bohaong.

Of Motinatina, a Grandson.

The ox of the spies of Ramabaleha (*i.e.*, Posholi, brother of
Moshesh),
Ox of Bokone, of Matebeleland,
Was searched for lice and horse-flies (*i.e.*, raw kaffirs).
The ox of the spies clears the mist,
The ox of Bokone of Matebeleland.
The builder of the battle heap of Government men,
The warrior fought to bring guns home.
Hero of the cartridges in little tins,
He fought at Mathebe,
When the night had cleared,
The night Poshodi was slain.

Information about the Family of Foregoing, Received at Tsikoane, opposite Ficksburg.

His son, Letina, said: Nkhahle quarrelled with Lechesa and the brother of Lebaka, *i.e.*, Tlaedi. Then the children of the Dikonyela (regiment) fought against our men, those of Lebaka, and our brethren slew them. Now chief Lechesa refused, saying, "Let them go"; they were his peōple, but they had already killed (some). Those of the Dikonyela departed, and they sent two mes-

sengers; they sent them to Bokone, to seek a doctor from thence. The doctor came, when my grandfather, Lebaka,* was a boy herding cattle—yet a chief, although he was still herding among the Dikonyela (regiment). They anointed a stick with medicine, then they threw it into the veld. When he (L.) came and jumped over the stick—he went mad. They were scattered when the chief was mad; some came through when they came hither to Moshesh, other remained in Bokone, others at Dikonyeleng.

These Batlokoa had special regiment names: Maphatsoe (No. 14), Maroala (No. 12), Masiu, Matsoetetsi (Lebaka's brother, was called after his grandfather, as often, and as in Greece); Maisaisane (v. No. 13), Mats'oara (Nkhahle's), Machesa (No. 11) about 1768, Matlatsa circumcised about 1805 probably; Likonyela of Sekonyela, 1821; and Mahana about the same time; and Matina before 1863, probably.

FURTHER BAKOENA PRAISES.

XVIII.

Of Sello.

The "cry" of the Mathiba regiment of Ma-ratenku and Tsotelo (or Ma-linku, or linko, and Tsotelo).

N.B.—*Sello* means a cry, and Tsotelo was his father's name.

XIX.

Of Malane, His Son.

Khongoana e tsholohali ea mathaha
Khongoana e ka mpuru Malane.

The big brown cow of the Canary regiment
Is like the conqueror Malane.

XX.

Of Namanyane (Son of Malane, and Elder Brother of Ngaka).

Sehoyanana sa MaMohatseli,
mohla se hapang letlole,
se hapa ts'oana e fine kharatsa(na) holimolimo,
thabeng Hlohloloane ho hloile batho, ho fina kharatsa(na).

* Actually his grandfather's maternal grandfather.

The feeble cripple of Mamohatsedi,
When he seizes on the prey (fat, smear),
He seizes the black cow adorned with a crest above,
Upon Mount Clocolan have men swarmed up to fasten on that crest.

Recollections of a Centenarian.

Motinatina said: When they left Ntsoananatsatsi, the Batlokoa came and fought Moshesh at Buthabuthe (1824). When they had scattered Moshesh, he went to Thaba Bosiu, and then Sekonyela came here to Tsikoane and went up into that mountain; the Bakoena of Marabeng and Mokhitle went and swarmed up Joalaboholo, so Sekonyela went and scattered Mokhitle there. The latter went to Moshesh and took refuge there. Sekonyela remained and built and settled at Joalaboholo. Molapo quarrelled with Letsie at Makhoarane, both claiming a leopard; one refused to leave it, saying it was his. Then Moshesh takes Molapo and gives him to Sekonyela. The latter's son, father of Ledingoana, burnt the house of Kadi: Moshesh and Seyonyela quarrelled and fought for ten years, and then in the twelfth year (1853) Moshesh scattered Sekonyela, and this land went back into Moshesh's power. He brought Molapo hither, as it already belonged to him.

Moshesh quarrelled with the Boers in the days of Senekal (1858). Afterwards Brandt came with the coloured folk and Constable,* who were to come and fight Moshesh in the war of Seqiti('66ff). Moshesh fought with the Boers eight years, and then came peace: there came Wodehouse, Currie and Bowker,* who were to come and fight in alliance with the Boers; they separated, and there came peace.

It is then the English came and made boundaries at the Caledon, cutting themselves off from the Boers. They made boundaries at Caledon. This whole land of the Orange Free State is the land of Moshesh: Moshesh's boundary was the Vaal; it is no longer so, it is the Boer's now.

The English quarrelled with the Boers; then the English called many sorts of black and white men, and so they scattered Paul (Kruger) who went to the Portuguese. I know that to-day the Queen has also quarrelled with the Germans on the sea!

From the Days of Childhood.†

When Moshesh went to Kobo's place, Khosi‡ was wounded there. Then the Batlokoa remained and attacked, seizing Mamo-

* The Suto pronunciation of these names is quaint: Kos-tabole, Kutausi, Kori, Bokoro.

† This informant with his son Letina both got their names from the Tina River, near the Tsitsa in Pondonisiland. The son was born just after his father's return from his campaign in those parts under Poshodi, Moshesh's younger brother (1861).

‡ Khosi when he praises himself says:—
I am the hero of Kobetsane of the Makhila regiment.
(He also speared the Xosas yonder, i.e., in Cape Colony.)
He said: I have pierced you, not seeing you.

hato (wife of Moshesh). Then they ran and stopped Mamohato and slew the Batlokoa: Mamohato returned home, and Moshesh praised (them) greatly, he found his children (they had been stopped by Tyakane's men—there were some heroes among them at Mphutlana's place—the mighty men of Nyakane slew the Batlokoa, Mokakailane the Motlokoa: so they stopped Mamohato. (1829: See Almanaka ea Basotho for the dating.)

Note on 'Mamosa, the Mother of Jonathan (vide IV.).

(Contributed by A. Sekese.)

Ramokotyo, the father of 'Mamosa, was a man of Makhabane, the brother of Moshesh. When Makhabane was proclaimed at Ntlokholo, he was out with Ramokotyo, and at that time Japje, a prophet of the war with the Koranas, which was still to come (1835), prophesied of the horses which they rode and an ox, which was ridden by Raleotoana, and also of his death, and of the guns. (At the time of that war 'Mamosa was circumcised at Ramakha with Masenate, Moshesh's queen.) He also prophesied of the coming of the missionaries.

'Mamosa then went back to Ntlokholo. At that time 'Mamosa was a little girl. She was frightening birds there, and was seen by the shepherds of Mokhachane and Moshesh. Tsieane Mokhachane wanted to marry her, but she refused him flatly, and Lesaoane also (he was engaged to Mamaneela). Molapo also saw her looking after his father's cattle.

Moshesh hastened to send Khoho, and ordered him to take a royal sheep in Mokotyo's charge and to ask him for 'Mamosa. Then they went out to Makhoarane (near Morija). Moshesh and his father sent Tsieane to follow him and Nkhase, Qusha and Makhoma, son of Letoka (a Mosia), in addition to his father's wives, including Manena Moshesh. At that time the missionaries had come, and when they were there Moorosi said he had been to look for the cattle at Kobo's (in Cape Colony); at that time Isaac praised himself and said:—

"Mphurane a phura thata, Baphiri."

(M. gnashed his teeth well, O men of the Hyenas regiment.)

Mosa Molomo was born; when they left Makhoarane they went to Peka, when Jonathan was born. They returned to Makhoarane, where Jonathan was baptised. Then they came to Cana; shortly after they left there because of trouble caused by Sekhonyela, and went to Tsoanamakhulo; when they left there they went to Leribe, where Japje prophesied the madness of Josepha.

ON SEVERAL IMPLEMENTS AND ORNAMENTS FROM STRANDLOOPER SITES IN THE EASTERN PROVINCE.

BY

JOHN HEWITT, B.A.

Director, Albany Museum, Grahamstown.

With Plates IX-XII.

Read July 15, 1921.

Pygmy crescents closely resembling those which have long been known from Europe were figured and described by the late J. P. Johnson[1], from Riverton Island, from Bulawayo, and from the junction of the Vaal with its tributary, the Hart River. They are not common in South Africa, being apparently absent from the well-known Strandlooper sites of the Western Province. In his monumental work,[2] Dr. L. Péringuey figures only one example, from the Orange Free State, giving no other record of this very characteristic type, although pygmy implements of various other kinds are figured and described from the sand-dune middens of the Cape Peninsula: nor does he mention the larger crescents, such as I now record from different sites on the coast of the Eastern Province. Nevertheless, the occurrence of pygmy crescents of this type has been reported to me by Mr. H. Harger from the dunes at Still Bay, near Heidelberg, C.P. In the Eastern Province pygmy crescents (Plate XI, Fig. 10) were discovered quite recently in a large rock shelter on the farm Wilton, near Alicedale, by Mr. C. Windsor Wilmot, postmaster of Qumbu. On that site, ornamented with numerous rock paintings, Mr. Wilmot found in the ash and débris of the floor a great quantity of small scrapers (Fig. 9) and ostrich shell beads, and together with them about a dozen or more crescents, all small yet beautifully finished, the length ranging from half to five-sixths of an inch, with a maximum thickness along the curved back of one-seventh of an inch. Some of them still bear traces of red paint on the edges, and in one instance the paint forms a more or less distinct line on the under surface, as if the maker of the implement had first outlined the curve in paint on the original flake. A single pygmy crescent was also found a few months ago in a rock shelter on the farm Berg Plaats, near Grahamstown.

A series of six larger specimens, rather coarsely made, but differing chiefly in size from the Wilton crescents, was found in a shell-mound near the mouth of the Nahoon River, by Mr. Jas. Swan: these (Fig. 10) are about one and a half inches long and four-sevenths of an inch wide. A still larger example, but broken, measuring originally about two inches by two-thirds of an inch,

[1] "The Pre-Historic Period in South Africa." 1912.

[2] "The Stone Ages of South Africa." Annals of South African Museum, Vol. VIII.

was found at Port Alfred by the Rev. P. Stapleton, S.J. Another, which seems to be the major half of a crescent, came from Port Elizabeth (June, 1896, Mr. Irniger). Lastly, an example with its cutting edge serrated was figured and referred to by Dr. Schönland as "a saw from Bushmanland" in "Records of the Albany Museum," II., p. 18. The locality of this specimen is probably incorrect, and I have good reason for believing that it came from Port Alfred.

All these implements are made of surface quartzite, which, however, varies considerably in appearance and composition, the Wilton crescents being of fine-grained homogeneous rock, and the Nahoon specimens of much more heterogeneous material, showing patches of translucent quartz. Except as regards the material used, these specimens seem to be identical with crescents described from far distant regions of the old world. Specimens quite like those from Wilton, but made of pure quartz, have been obtained in very great numbers on the hills in Ceylon by Mr. C. Hartley,[1] and others made of obsidian are recorded by the same writer from Uganda. Specimens from India are made of jasper and chalcedony, and those from England and various countries in Europe of flint. In Dechlelette's "Manuel d'Archeologie," pygmy crescents are also recorded from Syria, Egypt, Tunis and Algiers.

These and other pygmy implements occur both on cave and surface sites in Europe; but in France, at least, are specially characteristic of coastal and river-side middens, and were evidently made by people akin to our coastal Strandloopers in their mode of life. At most of these sites there is, however, a somewhat greater variety of form than obtains here. The typical crescents of Europe pass by various grades of intermediates into well-marked triangles: the same occur also in Ceylon and in Algeria, whence indeed rhombic and rectangular specimens are recorded.

This pygmy implement culture, known in France as Tardenoisian, was formerly regarded as referable to an early stage in the European Neolithic period. There was little direct evidence connecting them with typical Neolithic cultures, yet occasionally they have been found along with polished neoliths. A more modern view, expressed by Sir Arthur Evans in his presidential address to the British Association in 1916, connects this Tardenoisian with the Azilian period, which is a decadent offshoot of the Magdalenian, and as such, terminates the age of Palæolithic man. Between the Azilian and the commencement of the true Neolithic period, as represented in the Danish kitchen middens, there was in Denmark at least a considerable interval of time. Thus, according to either view, the pygmy culture in Europe belongs to some portion of that interval separating the men of the polished stone age from the cavemen of the reindeer age, who, like our Bushmen, decorated the walls of their dwelling places with paintings or engravings of animals.

In Ceylon, also, the stratigraphical evidence given by Mr. C. Hartley seems to favour a greater antiquity for pygmy implements,

[1] "Spolia Zeylanica," Vol. X, 1914.

compared with the so-called Neolithic types of that country.

But in South Africa, so far as I know, there is no stratigraphical evidence indicating their antiquity, for they are recorded only from surface sites. Nevertheless, the pygmy culture differs in technique as well as in size from that so frequently found on surface sites in the Eastern Karroo. I have seen hundreds of end-scrapers scattered over the slopes of a stony hillside on the farm Cossackpost, near Rosmead, and many others from central districts of the Cape, but none of them like the small rounded scrapers from Wilton, many of which are bevelled at both ends, and broader than long. The Cossackpost specimens, being made of lydianite, and often showing no signs of weathering, are presumably fairly recent, and may reasonably be referred to the "Bushmen" who frequented that region a little more than a century ago.

If the pygmy crescents and scrapers also belong to the Bushman race, as now seems equally probable, the two techniques may belong to distinct branches thereof, contemporaneous or otherwise. That such differentiation within the race did exist seems to me a valid deduction from the distribution data, even after making considerable allowance for local variations and developments of technique, for Dr. Péringuey tells us that bevelled scrapers are seldom found in the Western part of the Colony, yet they abound in the Karroo and are met with in the Orange Free State, Griqualand West, and southern parts of the Transvaal. Such bevelled scrapers are the characteristic elements of the implement assembly at Cossackpost, and the same are figured by Johnson from Modder River.

Or, again, differences in actual size of implements may possibly betoken the sex of the maker. According to Dr. Kannemeyer, who claims to have learned the fact from more than one person intimately acquainted with Bushmen, it was usually the women who made the stone implements, but the arrow straighteners, and doubtless all the weapons, were made by men. The large implements used for what may be called domestic purposes, such as grinding, weights for digging sticks, etc., are often found in the springs; they were too heavy to carry about, and the Bushmen consequently hid them in the springs or in stores. It was a Bushman custom to fill up and cover over the springs to conceal them from white men.[1]

Thus, it should not be assumed that the implements found in a well-filled rock-shelter, or any other aboriginal site, actually affords a complete representation of the tribal workmanship.

On the aboriginal sites of the Free State and the Transvaal there have also been found two groups of scrapers, contrasting in size, in reference to which P. P. Johnson wrote: "Mons. Rutot judging from my figures, suggests that the Riet and Modder group of solutric implements are Aurignacian, and that the Taaibosch group corresponds to a late phase of the solutric stage of West Europe, which he terms pre-Tardenoisian, and which is charac-

[1] "Man.," 1907, No. 35, p. 50.

terised by the smallness of the implements." But Johnson himself rejected any such explanation of the disparity in size. He laid stress on the fact that the large scrapers are all made of lydian stone and the small ones from small pebbles of jasper or agate. etc.; and, in his opinion, the character of the scrapers on any particular site was determined chiefly by the nature of the available material. The two types seemed to him of the same class and contemporary.

My own opinion, based on the Wilton data, favours the suggestion of Mons. Rutot, no assumption of age being involved. The workers of this site certainly had no opportunity of using lydianite, yet they nevertheless succeeded in making numerous comparatively large flakes from a local fine-grained surface quartzite. Most of these flakes, which are very thin, measure in length from one and a half to two inches, and, no doubt, scrapers of corresponding size might easily have been made, if desired; but such large scrapers are almost entirely absent from the Wilton collections.

However this may be, a Bushman origin for the Wilton crescents may be inferred from the cultural associations. The ostrich-shell beads and rock paintings suggest that conclusion, but additional weight is given from the fact that an adult skull (Plate XII, Fig. 14) clearly referable to some branch of the Bushman race, was unearthed from the same rock-shelter. This skull is now in the Albany Museum, having been presented thereto by Mr. W. W. Wilmot, the owner of the farm. It agrees with the type differentiated as Strandlooper by Dr. Shrubsall, being just brachycephalic (Index 80), as also is another much younger specimen from the same place.

Remains of four burials, all probably of the same race, were found at the rock-shelter, and in each case the corpse had been covered by large flat stones painted with red on their under surfaces. Despite the fact of definite burial, we may assuredly connect the skeletons with the other objects above mentioned. Many of the beads were taken directly from the skeletons: others were found in the débris of the floor, along with pygmy implements, some of which were made, in all probability, for use in the bead industry. The same association of beads with pygmy implements is recorded from up-country sites by Johnson, and may be accepted as original.

The use of red pigment also affords a probable connecting link between the crescents and the skeletons, yet considering its prevalence from the cave period of Europe up to recent times, it is not alone sufficient to prove the genuineness of the association. It is nevertheless interesting to note that red haematite has been found on Tardenoisian sites in the region of the Meuse. However, as long ago as the first division of the reindeer age, the Aurignacian period, it was customary to bury lumps of red ochre with the dead so that they might make a fitting show in the under world. I may add that on various sites in Europe, in both Palæolithic and Neolithic times, human skeletons extensively stained with red on the skulls and bones have been found. Some

authorities have even suggested that the practice of colouring the dead was performed after decay of the flesh, a view which is not generally accepted. I mention this by way of recording the fact that such reddened skulls are also known to me from another cave near Alicedale, on the farm Spitzkop, the associated objects being apparently almost modern. The meaning of this ancient custom is well explained in some lines by Schiller in Nadowessier's "Todtenlied," as quoted by Sir Arthur Evans:—

"Colours, too, to paint his body,
Place within his hand,
That he glisten, bright and ruddy
In the Spirit-land!"

No direct evidence connecting the rock-paintings with skeletons and associated objects was obtained at this site. Yet the occurrence of minute scrapers and pygmy implements near to rock-paintings is not likely to be a mere coincidence, for similar associations have been recorded by Johnson from various up-country sites. This authority definitely associates painting with minute scrapers of the kind he obtained at Taaibosch. According to the published illustrations, the latter implements present very considerable resemblance in size and technique to some of the Wilton specimens, but the prevalence of rounded scrapers and of short broad specimens bevelled at both ends, as found in the Wilton series, does not seem to occur at the sites mentioned by Johnson, although he records the same small circular scrapers made from the half of a pebble in great quantity at Riverton. Actually, most of the tiny scrapers were end-scrapers which, he thought, had been either bound or cemented to a handle. On the other hand, Johnson found no specimens of his larger Modder River type of scraper at the rock-painting sites.

In attempting to determine the unity or otherwise of the association found on such a site considerable importance would generally be attached to the presence or absence of cultural strata. Now, the floor of the rock-shelter at Wilton is covered very largely by ashes, which in places have a vertical depth of four feet, but no layers are traceable therein. This is the unanimous conclusion of three investigators (Revs. P. Stapleton and Kilroe, and the writer) who devoted five days to its exploration.[1] Moreover, with few exceptions, the Wilton implements seem to constitute a homogeneous assembly, despite considerable range in size amongst the scrapers. Yet, on the morphological characters, I think it probable that two or more cultures are intermingled: the predominating culture is that of the pygmy implements and small rounded scrapers mostly made from fine-grained surface quartzite and generally trimmed with great delicacy: there is a small minority of larger implements much more coarsely flaked, and with these, perhaps, may be associated several typical end-scrapers comparable to those frequently found in the Eastern Karroo. The thin flakes previously mentioned may belong to either group or

[1] Mr. W. W. Wilmot, the owner of Wilton, rendered us much assistance during these operations, and all material collected on the two sites was generously presented by him to the Albany Museum.

to both. Lastly, a single perforated digging-stone (Kwe) and several oval palettes, made of shale, probably do not belong to the dominant culture, for the latter at least are not known from the Tardenoisian sites mentioned by Johnson; whilst, on the other hand, both these neoliths occur in a cave devoid of tiny scrapers at a locality not far from Wilton. The palettes were, nevertheless, found in the lowest layer of the ashen floor, but may have been deliberately buried.

Amongst the numerous paintings on the inner wall of the rock-shelter are some spirited representations of antelopes in profile. The technique is quite superior, and a number of the antelopes are in two colours, red and creamy white, but there are no group scenes. A very distinctive feature is the treatment of the human figure, the limbs and body being tremendously elongated. These, which are wholly red, may not belong to the same period as the antelope pictures. There are also at the same site a few paintings that are most obviously referable to comparatively recent intruders, possibly even refugee Hottentots. They include very crude illustrations of fat-tailed sheep (Fig. 11), painted apparently in a whitish clay, overlying the red pictures of earlier artists. This evidence, added to that of a few scraps of coarse pottery, picked up only on the surface or just below, seems to favour the conclusion derived from the implement data, that a superimposed culture occurs there. Considered separately, not one of these facts is conclusive: the inferior paintings and the end-scrapers may be individual variations, whilst the scanty pottery may have been introduced accidentally. But, connecting the three together on the strength of the modernity of these paintings and the pottery, we seem to approximate to the cultures of Strandlooper sites in the Eastern Karroo. Such hypothesis scarcely affects the strength of the argument connecting the skeletons with the dominant culture of this site.

Thus we arrive at a conclusion which has long been anticipated, but not hitherto so well supported by actual data as now detailed, that *the short-headed Bushman made the delicate ostrich-shell beads, the pygmy crescents, and the tiny scrapers, and was also the author of rock-paintings of superior and characteristic technique.*

Further, if the end-scrapers are correctly referred to the same culture as the pottery, we are entitled to regard the pygmy culture as an earlier one, not contemporaneous therewith, as Johnson supposed was the case in the Transvaal and Free State. At Wilton the evidence is certainly unfavourable to correlating pottery with pgymy implements, and is thus in agreement with the view that the primitive Bushmen did not make pottery. Yet, in the up-country sites, pottery and pygmy implements have often been taken together. It may be noted that the Azilian culture of Europe is also devoid of pottery and of polished stone implements.

The difficulty of interpretating the evidence of burials is illustrated by the case of a certain small cave two miles away from the rock-shelter, on the same farm, Wilton. In this cave—

which contains a number of red paintings, mostly very inferior and all very indistinct—were found pygmy crescents and small rounded scrapers as before, but, in addition, a considerable number of coarse flakes and large end-scrapers, more or less like those from Cossackpost or Modder River: and pieces of coarse pottery were relatively much more plentiful than at the rock-shelter. The floor of the cave was covered with ash and débris forming a layer nowhere more than two feet deep, usually less, and in it were the shallow burial places of four people, the skeletons, as before, being covered over by flat stones painted red on the under surfaces. In several cases a few bone beads and great numbers of ostrich-shell beads, were found with the skeletons, which beads, like those at the shelter, were small and delicate, much smaller indeed than those made now by the Kalahari Bushmen.

Now, the skulls from this cave are not of the orthodox Bushman type. One is markedly long and narrow, being distinguishable at a glance from skulls ordinarily attributed to Bushmen: two others are also distinctly too narrow and too high for such identification. They may, however, contain a Bushman element, if the characters of the mandible and the shape of the eye-sockets have any racial importance. These burials, in any case, cannot be very ancient, the skeletons being penetrated and largely absorbed by the roots of shrubs growing at the entrance of the cave. A relatively modern age for the skulls is also in agreement with Dr. Shrubsall's conclusions that the oldest type of Strandlooper aboriginal was more short-headed and orthognathous than recent types.

In the light of knowledge obtained at the rock-shelter, my interpretations of the data are as follows. The skulls belong to a comparatively recent branch of aborigines. Some of the bone and ostrich-shell beads are certainly associated therewith, and probably also the pottery and the end-scrapers. The pygmy crescents and small round scrapers may possibly belong to the same association, but are more probably relics of earlier occupants who made temporary use of the cave, the same people who lived in the large rock-shelter. The ostrich-shell beads may, on this view, belong to both cultures, for we know that they have persisted as the characteristic ornament of Bushmen up to the present day, long after the use of stone implements was abandoned: but the bone beads belong mainly, if not entirely, to the later occupants. I had provisionally arrived at these conclusions some months before they received support from data obtained at another small cave on the farm Spitzkop, some six miles away from Wilton. On this site a number of skeletons were unearthed recently by Mr. W. W. Austin. These agree well with two found in the Wilton cave, being relatively long and high, not flattened on the vault, and very noticeably prognathous. A great number of bone beads was found with them, also shell beads, a few pieces of pottery, a stone borer suitable for grinding the perforation of digging stones, and several elliptical stone palettes with ground edges,

but not a single crescent nor any small or rounded scrapers. The Spitzkop implements are nearly all flakes, many of them of the kind popularly spoken of as arrowheads. They are the predominating implements of the caves around Grahamstown (Plate X, Fig 6), and presumably Dr. Péringuey referred to this type when he wrote "with our paintings are associated simple small flakes of a type and size which are met with nearly everywhere." Such implements are apparently the productions of the most recent aborigines of the Albany district, and no doubt the Spitzkop skeletons (Fig. 15) belong to that now extinct race. Culturally, these people belonged to the Neolithic period, as indicated by the pottery and the polished stone implements—palettes and digging stones. There is another very characteristic implement which I do not hesitate to refer to these same people; an axe, or adze, with a carefully-ground cutting edge (Fig. 7). This has quite a striking general resemblance to the European Neolithic axes, but is made of local rock. It was found on the farm Vaal Krantz, which is but a few miles away from Spitzkop. It was not taken *in situ*, being picked up amongst other stones which had previously been excavated in making a water furrow. The specimen has been described and illustrated both by Schönland and Péringuey, but hitherto its connection with recent aborigines was not even suspected.

Regarding the relative ages of the two cultures here distinguished, in the absence of stratigraphical data we have at present no evidence more important than that of the paintings. There are no paintings on the walls of the Spitzkop cave, the surfaces being much broken up, but a coloured funeral slab of stone found in the bottom layers of the cave, overlying a skeleton, bears crude paintings which somewhat resemble the very inferior later paintings—the fat-tailed sheep group—found at the Wilton rock-shelter. This certainly adds weight to the argument for two or more cultures at Wilton, and helps to justify our segregating those inferior later paintings with the larger implements: but there are no means of estimating what period separated the two cultures.

The larger crescents from Nahoon seem to me very like one or two specimens recorded by Prof. W. J. Sollas from Paviland Cave, in Wales.[1] He refers the Welsh material to the Upper Aurignacian period, the characteristic implements of that subdivison being the "Gravette point," "a long, straight parallel-sided flake, generally triangular in section, one edge of which has been completely removed by minute and thorough retouching." In the Gravette point, the retouch on the worked edge is almost constantly directed from below upwards, which is certainly the case in most of the South African specimens, but not all. However, many Paviland specimens differ from ours in that they are pointed only at the apex, whilst the base of the flake remains untouched. The undoubted resemblance in technique becomes more remarkable inasmuch as the Gravette point passes into

[1] "Journal Royal Anthropological Institute," Vol. XLIII, 1913.

minute forms in Europe, one of which, figured by Sollas from the same cave, agrees very well with several of the pygmy crescents from Wilton: it differs from the majority of our crescents only in presenting no trace of the small facet that commonly occurs on the supper surface of a Wilton specimen at its widest part. *We may, therefore, provisionally regard the large crescents from coastal shell-mounds, and the pygmys from inland caves, as complementary, and referable to the same people*: it must be understood, however that the shell-mounds may include the cultures of various races, these mounds being largely unexplored.

The actual process of manufacture was evidently the same for all sizes of crescent. Owing to the supposed difficulty of trimming into shape the parent flakes, it has been suggested to me that many of the pygmy crescents are merely chips deliberately knocked off from the cutting ends of scrapers by way of renewing the edge. The specimens themselves bear no marks that would necessarily follow such procedure, nor have we found scrapers from which such chips were removed, although the Rev. P. Stapleton has examined some hundreds of scrapers to test this view. There can be no doubt that all these crescents were made from parallel-sided flakes. Larger flakes were sometimes converted into crescents by working one edge into a curve at each end, the middle portion of that edge remaining untouched. More often, however, the whole of that edge was worked, and it follows that, at the widest part, about the middle of the implement, the worked edge is narrower than at points in a line with the dorsal ridge. In one example from Port Alfred the curved edge has been carefully flaked throughout its length by percussion from above, and there results a sharp cutting edge which would make the implement quite useful as a two-edged knife. But in most specimens the crescentic edge is a blunt one, quite unsuitable for use as a knife, any acute edge that may once have been present being destroyed by vertical pressure or blows from below.

There is a very interesting note on "Pygmy Implements from the sand-dunes of Fish Hoek, Cape Colony," by Mr. W. J. Lewis Abbott, in "Man," September, 1913. Some of these are described as crescents, although they are quite different from those I have just described, having both edges conversely curved and bevelled: in size and delicacy of flaking they recall the Tardenoisian cultures at Wilton and Taaibosch, but the shapes are different. A great number, taken close to the sea or in the neighbourhood of vleis in the south-western part of Cape Colony, are figured in Dr. Péringuey's book, Pl. 18, Fig. 143. Mr. Lewis Abbott was much impressed by the fact that the methods employed in making such implements were apparently much the same in South Africa as in Europe. He refers the pygmy implements of the French caves to two main groups according to the mode of manufacture. In some cases the characteristic edge-working was in all probability effected by a strip of bone with a sawsetter slot. In others they were made by the removal of old edges of scrapers and burins by a blow administered at the point or butt when it was desired to put on a new edge. Both types he claims to have identified

in the Fish Hoek material. In the former group, made with a slot-work apparatus, some of the Fish Hoek specimens indicate that "in running the flaker up the edge, the backward and forward movement took off the tiny flakes from both faces, giving rise to an almost rectangular edge," but in others such is not the case.[1] In the Wilton material, however, I can find no specimens showing a rectangular edge thus formed, nor any which are merely the old edges of scrapers and burins. In the Paviland Cave, on the other hand, "numerous small flakes occur which could never have been retouched in their present state: they are no doubt the worn ends of burins and scrapers which have been struck off to renew the edge."—(Prof. Sollas.)

Various suggestions have been made on the former use of such crescents. The most acceptable view, in my opinion, relegates them to the category of hooks or throttles for catching fish or other prey. This is based on the fact that in many cases the only serviceable part of the implement is the sharply-pointed ends: these are certainly the only constant features of crescents.

Further, these implements are chiefly, if not invariably, found in the middens of ichthyophagous peoples.

An aboriginal site on the banks of the Great Fish River, near Cradock, has long been known. According to Mr. Hubert James, there are extensive middens about 50 to 100 yards from the banks of the river, which are covered by three to five feet of alluvial soil, except where this has been removed by erosion. These middens are very abundant along the Fish River, both above and below Cradock, and are also found on the Tarka River. Implements therefrom have been described both by Dr. Péringuey and J. P. Johnson, and the site is noteworthy as being the only one in the Cape whence well-shaped arrow-heads have been taken, although inferior examples are recorded by Péringuey from Queenstown. I have lately had the opportunity of examining two such arrowheads found by Mr. Hubert James, on a Fish River site at Halesowen, on which specimen the following notes and illustrations are based.

The larger example (Plate IX, Fig. 2) is of black lydianite, quite unweathered. The tang is sharply defined from the body of the implement, and has been very carefully worked all round, the bulb of percussion being removed. Otherwise the general surface above and below remains as in the original flake, except that in the apical half of the implement both edges have been trimmed on the upper side, and one edge towards the tip on the lower side. The length is 2.9 inches, breadth 0.7 inch, and greatest

[1] I take this opportunity of drawing attention to a remarkable record given in the same paper by Mr. Lewis Abbott. He saw a collection of crescents similar to the above in all respects, in technique and material, labelled as from Australia (Miss Nina Layard) in the Ipswich Museum. This would be important, if correct; but in view of the fact that such implements have not otherwise been recorded from Australia, so far as I can ascertain, and that Mr. E. L. Layard was for many years the Curator of the South African Museum, Capetown, there seems room for suspicion of error in the locality.

thickness 0.15 inch. The carefully-made tang and the well-shaped pointed end are the special features of this specimen.

The other example (Fig. 1), measuring 2.7 inches by 0.7 inch by 0.25 inch, is similar, except that the tang passes gradually into the body of the implement. The bulb of percussion has been removed, but there is no other retouching on the faces of the implement: the edges are delicately trimmed throughout, above and below. The material has weathered grey. This specimen has a general resemblance to several of the arrowheads recorded from Egypt by Flinders Petrie in his paper "The Stone Age in Egypt"; but other arrowheads, figured on the same page and likewise referred to the Solutrean technique, are much superior to the Cradock specimen.

Dr. Péringuey also figures several small arrowheads from the Free State, representing a technique decidedly superior to that of the Cradock specimens. One of them, from the Caledon district, was found "among South African-type pygmy scrapers," but these pygmy scrapers are evidently quite different from those found at Wilton, if the specimen figured by Péringuey is a fair sample.

Associated with the arrowheads at Halesowen were typical end scrapers. Those lent to me by Mr. James are of superior type, being delicately trimmed, like the arrowheads. They are all rather flat, some long and some short. In addition, there were numerous flakes, several broken kwes, a grooved stone (presumably used for making bodkins), many fragments of pottery, a bone bead, and a pendant of unusual shape, made of ostrich shell. Pendants made from marine shells are not uncommon in the Strandlooper caves of the southern coast, but, unlike this specimen, are usually regularly oval and much longer than broad. The shape of the Halesowen specimen can be seen from the illustration (Fig. 13). The disc measures about 1 3-5th in. by 1 3-7th in., and on the concave inner side is a simple incised decoration throughout the margin. This apparently commenced as a series of short more or less radial lines which were afterwards connected up into a zigzag by lines more obliquely disposed. The upper portion of the pendant is missing, the line of fracture passing through a hole that had been pierced therein, and we may surmise that there was originally a pair of holes.

The immediate interest of this specimen lies in the fact that we have one of similar shape from the Spitzkop rock-shelter (Fig. 12). The latter was, however, cut out from some large marine shell, and is quite flat. It has a decoration of incised short lines obliquely cutting the margin of the inner surface, but these lines are not crossed. The specimen measures 33 mm. by 29 mm. A still smaller one, from the same shelter, measuring 21 mm. by 18 mm., has a notched decoration around the margin, but is cut out from the shell of some gastropod, and is longer than broad.

This indication of affinity between the cultures of the aboriginal sites at Cradock and at the Spitzkop cave is supplemented by one of, perhaps, even greater importance in the

pottery. At both sites we find red pottery of the type designated Strandlooper by Dr. Péringuey: it is ornamented with parallel incised lines around the rim externally, as is often the case in pottery from Port Alfred and other coastal sites. The distribution of such decorated pottery has not yet been worked out in detail, but its importance in discriminating between the cultures of the various aboriginal types may be assumed.

Thus we may reasonably suppose that the cultures of the Cradock middens and of the Spitzkop cave are referable to the same people. It is neolithic, and not strictly comparable to that of the European cave period, as is sometimes stated on the evidence of the end-scrapers. Here I may add that in a review of Johnson's book, published in "L'Homme prehistorique," for June, 1909, exception is taken to the author's identification of his South African material with the Solutric group of Europe. The reviewer states that our material has only a vague analogy with the Solutrean, and can be more justly compared with the Tardenoisien, "dont elle se rapproche par ses petits nucleus, ses petits grattoirs, ses fines lames taillées en pointe, et ses minuscules instruments de formes geometriques en silex, jasper, etc."

This view can be reconciled with that now put forward when it is remembered that Johnson's Modder River group of implements, composed chiefly of large end-scrapers, included no such typical neoliths as those now recorded from Spitzkop and Vaalkrantz. It seems clear that end-scrapers are of little value in differentiating allied cultures

Some Coastal Neolithic Implements.

The coastal middens of the Eastern Province have not been systematically explored, and we know nothing of the sequence of cultures they may contain, beyond the fact that the shell-mound implements are of very varied technique. The Neolithic culture is represented by kwe stones, some in the process of making, and by pottery of the type hitherto mentioned. The following superior speciments I am also inclined to refer to this culture. Three flake implements from Kleinemonde, Bathurst coast, collected many years ago by Dr. W. G. Atherstone. They (Figs. 3 and 4) are in the form of small, but fairly thick, lance-heads, one long and narrow (63mm. by 22mm.), the others much broader and a little shorter (59mm. by 35mm., and 56mm. by 30 mm.) In each case, the upper surface of the flake has been worked all over, the dorsal ridge being thereby obliterated: the butt has been rounded, and the bulb of percussion has been completely removed by surface flaking; otherwise, the lower surface of the original flake remains untouched. The dorsal flaking is rather delicate in two of the specimens, but in no case has any attempt been made to seriously reduce the thickness of the specimen.

Such implements are not known to me from local caves, nor from shell-mounds on the Great Fish River, but a single specimen

collected by Miss Mary Bowker on a surface site near a tributary of that river, on the farm Cossackpost, near Rosmead, greatly resembles the narrow implement from Kleinemonde, but is larger, being four inches long, and seems to have had no bulb of percussion. The Cossackpost specimen (Fig. 8), is of black lydianite, not weathered, and the same site has yielded numerous large end-scrapers and flakes.

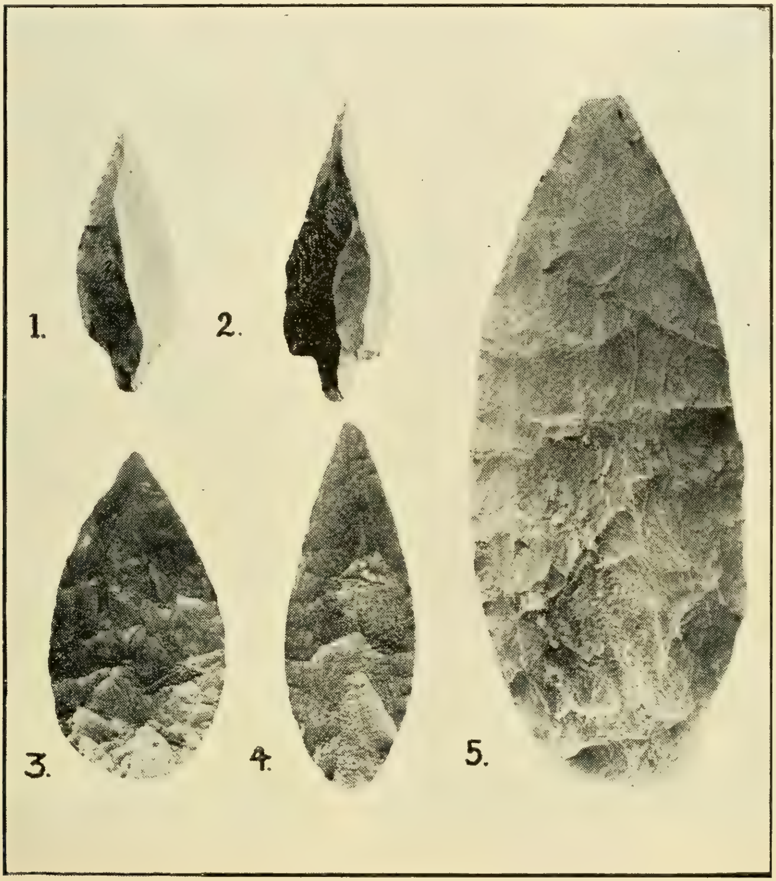
Lastly, there is in the Transvaal Museum a fine large spear-head, which, according to the authorities of that institution, was probably collected near Port Alfred. The surface quartzite from which it was made is not quite like that of any Port Alfred specimen in our collection, and there is no pitting nor gloss such as exposed implements acquire at the coast. I believe nevertheless that it must have come from some part of the southern coast, which view is also maintained by one of our most experienced geologists, Professor E. H. L. Schwarz. The specimen (Fig. 5), is noteworthy for its characteristic shape, but the surface flaking is comparatively coarse. It is worked from a flake on both faces almost throughout, except that the mesial portion of the original lower surface remains untouched over a considerable area; the original surface is also present at the truncated butt end, which is triangular. There is no trace left of the dorsal ridge, except possibly just at the base, and the bulb of percussion is quite obliterated. The edge all round is rather sharp and slightly sinuous, as in "bouchers," owing to the alternative flaking. The edge working is nowhere very fine, but moderately fine trimming occurs towards the tip of the implement. The length is 4.8 inches, breadth 1.9 inches, thickness 0.62 inches. This specimen has some likeness to the best type of Palaeolithic "boucher," but differs from any such specimen in our collection, not only in shape, but also in its thickness: in this latter respect again, it differs from the typical leaf-shaped implements of the Solutrean period, which are markedly thin.

Conclusion.

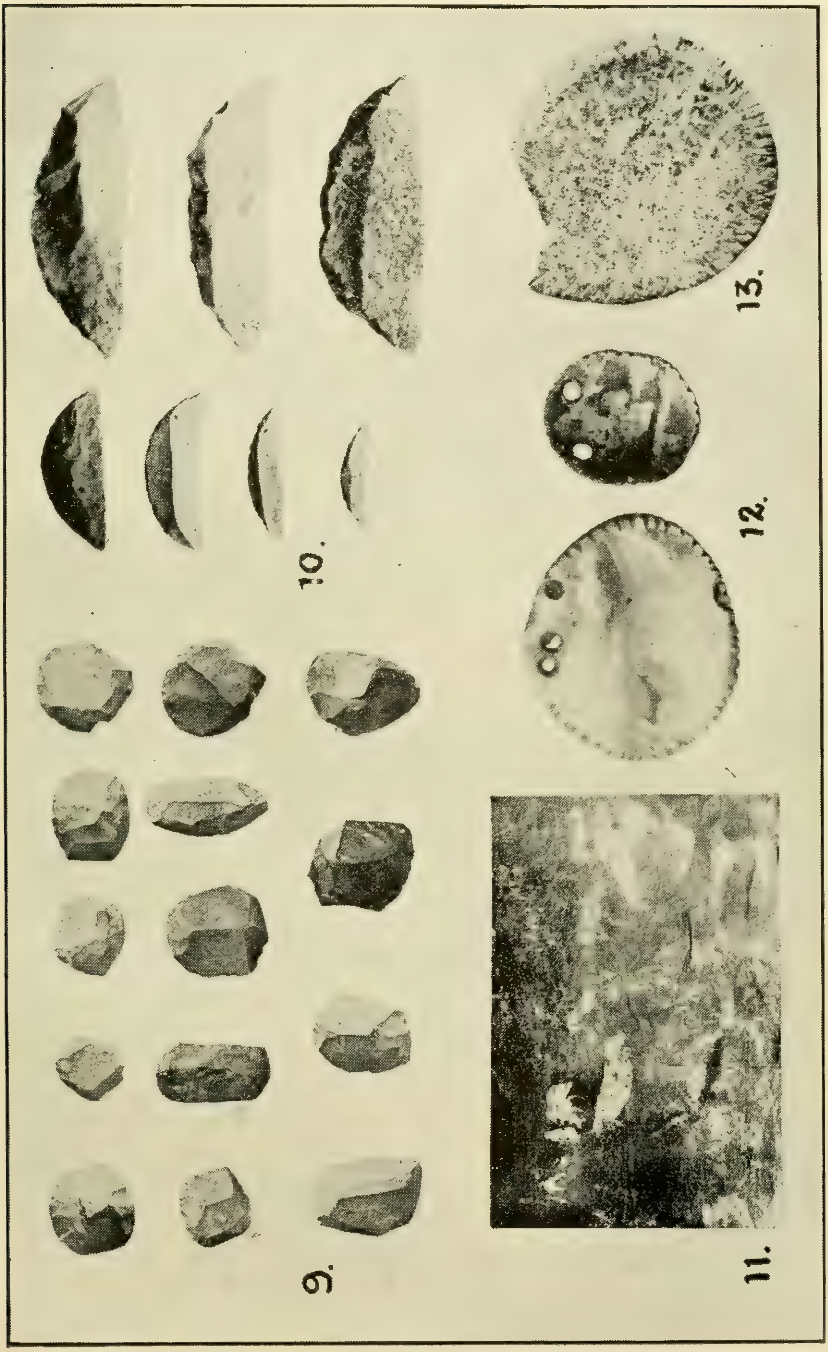
On their morphological characters, the stone implements found on several cave sites in the Albany district seem to belong to at least two distinct cultures. The rock paintings occurring at such sites are also of several techniques, including superior bichrome representations of antelopes and very inferior figures of fat-tailed sheep, the latter being of more recent age. Two types of human skulls have been found in the same caves, one short-headed and prognathous and other mesaticephalic and very prognathous.

Although the evidence is somewhat incomplete, there is sufficient to make the following correlations highly probable:—

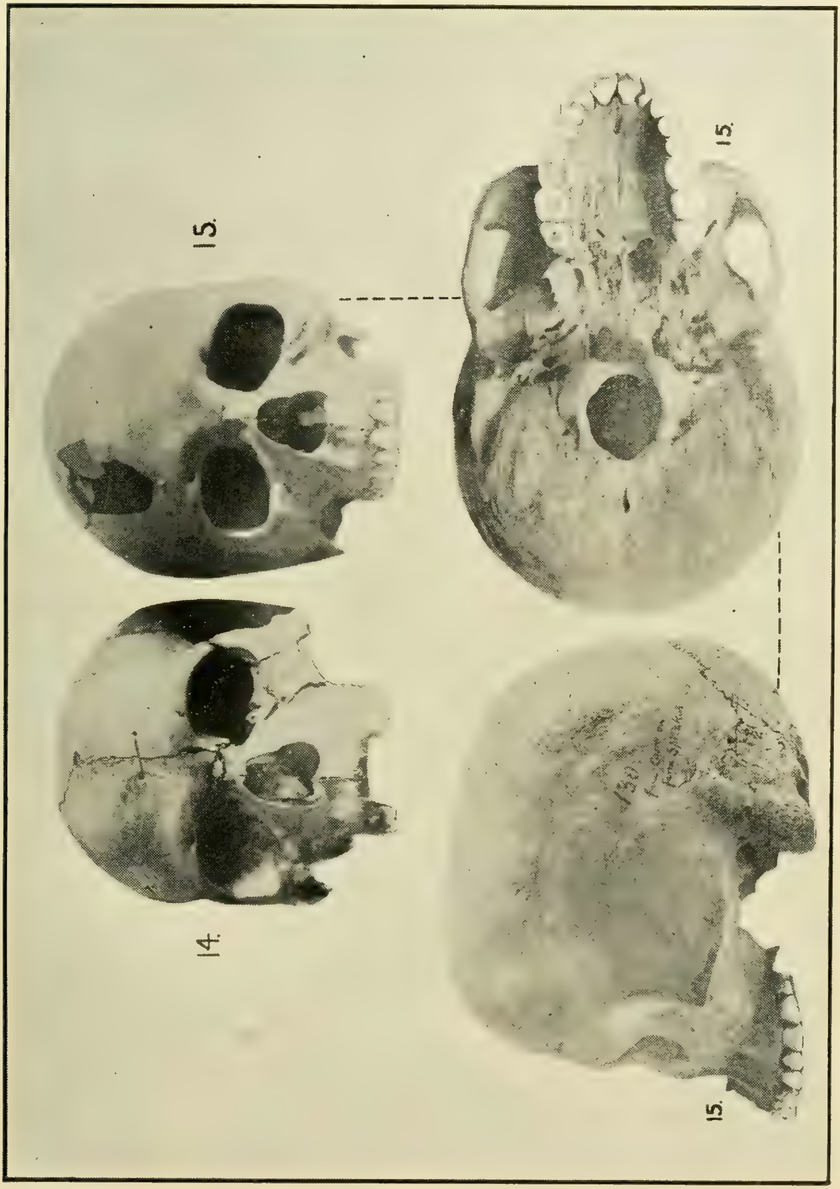
(1) *Shortheaded orthognathous "Bushmen"* (*alias* Strandloopers of Dr. Shrubsall), makers of crescents and pygmy implements of all kinds, also of very small ostrich-shell beads, painters of the best animal figures, date uncertain, but probably earlier than (2), lived in caves and also at the coast.



STONE IMPLEMENTS FROM STRANDLOOPER SITES, EASTERN PROVINCE.



IMPLEMENTS AND ORNAMENTS FROM STRANDLOOPER SITES.



SKULLS FROM STRANDLOOPER SITES.

(2) *Prognathous "Bushmen"* (they probably belong to some historic tribe* Damasonqua or Gonaqua Hottentots), makers of end-scrapers and of occasional lance and arrowheads of superior type, also of Neolithic implements such as kwes, palettes, stone-axe, makers of characteristic pottery (designated Strandlooper by Dr. Péringuey), workers in bone and ivory, bone beads to a considerable extent supplanting those of ostrich shell, although ornaments cut from shells of molluscs and of ostrich egg were abundant. Date fairly recent. Lived in caves, also on the banks of the Great Fish River, near Cradock, and at various places on the coast.

It may be noted that this is in agreement with the sequence of cultures in Europe, in so far as the stone implements are concerned, the pygmies of the European Tardenoisian being prior to the ground and polished implements of the Neolithic age.

Explanation of Plates IX-XII.

Plate IX—Arrow-heads from river-side midden at Halesownen (Figs. 1 and 2): lance-heads from shell-mound at Kleinemonde (Figs. 3 and 4): spear-head from unknown locality, probably southern Cape coast (Fig. 5), noteworthy amongst the flake implements here figured in being worked throughout on both surfaces.

Plate X—Flakes from rock-shelter containing paintings at Glencraig, Grahamstown (Fig. 6): Axe with ground edge from Vaalkrantz (Fig. 7): Lance-head from surface site at Cossack-post, near Rosmead (Fig. 8).

Plate XI—Small scrapers from Wilton rock-shelter (Fig. 9): Four small crescents from Wilton rock-shelter and three large ones from Nahoon shell-mound (Fig. 10): Inferior paintings at Wilton, including two fat-tailed sheep on the left (Fig. 11.): Pendants of sea shells from Spitzkop cave (Fig. 12): of ostrich shell from river-side midden at Halesowen (Fig. 13).

Plate XII—Skull of short-headed "Bushman," male, from Wilton rock-shelter (Fig. 14): Of prognathous "Hottentot" female, from Spitzkop cave (Fig. 15): Three views of the latter are shown.

---

* A summary of the historical data relating to the Aborigines of the Eastern Province may be found in a paper by the present writer, published in "S.A. Journal of Science," July, 1921.

THE FUNCTION OF A SCHOOL OF ART IN THE LIFE OF THE COMMUNITY.

BY

O. J. P. Oxley, A.R.C.A. (London),

Art Master, The Technical College, Durban.

Read July 13, 1921.

This paper is in the nature of a plea for a more universal and a fuller recognition of art education in a practical sense, and to show the relationship which ought to exist between a school of art and the life of the town in which it is situated. Where art is concerned, educationalists have always viewed the subject from the narrow and the least profitable standpoint. Draughtsmanship and painting have almost excluded other forms of instruction, and it is owing to this limited outlook that art in educational systems has received little or no consideration. Until this view is altered there is little hope, or reason, for us to expect any improvement. To-day in England, France and America a wider and more liberal type of instruction is finding favour in all departments connected with education. It is necessary for authorities to make up their minds as to the kind of education they intend to work for; and if they really mean to regard the school as the place where a beginning is to be made for the pursuit of truth, a clear and sincere outlook is essential, for education is just sincerity, and one must know a great deal to be sincere.

The Head of a school of art should be possessed of a good knowledge of the educational nature of, and forms of instruction in art. By virtue of his training and position, the head should be consulted on all matters of art training, and he should have control of all art instruction in the town. By proper organisation there should be an unbroken chain of instruction from the kindergarten to the end of the secondary school period, which should, if necessary, be continued in the school of art or training college. By the linking up of the primary and secondary schools with the school of art, the whole of the instruction would receive a wider outlook, and the prevailing idea that the drawing-board, paper and pencil are the only essentials for this subject, may be gradually changed. The development of appreciation is of more value ultimately than skill in drawing, and our future education should aim at inculcating the appreciation of beauty, of art and craftsmanship. It is the eye, and not the brain, that first awakes the passion for the beautiful. It is the business of the school of art to open up all avenues of beauty, and this fact should never be lost sight of.

In what direction other than the drawing up of the various syllabuses connected with the curricula of the primary and secondary schools can the school of art help the schools of the town? The art master is rarely consulted about the painting and

decoration of the schools, the pictures, the printing of stationery, notices, and books used by educational authorities. The authorities consult their engineer, treasurer or surveyor on matters peculiar to their departments, but they rarely think of using the art master—who is also a public servant—on matters relating to his profession. It is no more costly to have matter printed in legible types and set up in an orderly manner, or the class room decorated in a harmonious way. In far too many instances there is no evidence of any thought or brain work displayed on the part of those who set up the type, or any consideration given to the selection of school pictures and their arrangement on the walls of the school.

Short talks may be given to the pupils in the upper standards of the primary and secondary schools, dealing with the various crafts, and the history of art generally. These should be correlated with history, geography or literature lessons. Get our boys and girls to realise that the fertility of the Nile Valley made civilisation possible, and so produced the ancient art of Egypt; and that the rude construction of, say, Stonehenge, is but the building principle of the Parthenon without its refinements. A Greek temple of radiant marble, with its sculptured gods and goddesses, its ordered plan and simple and expressive lines, is a reflection of the mental development of the Greek race. Their whole art is the counterpart of the investigations of Socrates concerning a definition. The imperial instinct of the Romans, and their mission to conquer and rule, finds outward expression in Roman architecture, not in Rome alone, but to the very outskirts of the empire. The decline of this empire is written clearly in the language of art. In the decoration of Santa Sophia, with its absence of the use of the human figure, we still hear the echoes of the theological disputes and arguments of the iconoclasts. The wonders of the European cathedrals recall the height of the church power. The Renaissance may be given its proper meaning, instead of remaining a high-sounding word. The period which sent men forth to explore the unknown seas and make navigation a scientific calling gives us scientific architecture and sculpture. The advent of machinery may be seen in the hopeless artistic state of the 19th century, with its Gothic and Renaissance revivals.

I believe that art viewed from this standpoint could be advantageously introduced into our schools with the result that the future generation will learn to regard the past with interest, and to feel that expressing itself through any form of art would be only carrying on a great tradition. This co-ordination with the elementary schools is, to my mind, an essential, to assure the community receiving full benefit from its art school. The foregoing instruction naturally takes place outside the school of art, and for its accomplishment the staff are the only ones affected.

When considering the actual work within the school one of the most important aspects to be regarded is the relation between industry and the school curriculum. It is to be taken for granted that the school is in close touch with the employers and employees

of trades which it can serve. Local societies should be encouraged to hold their meetings in the school, and every possible endeavour made to strengthen the tie between the school and industry. It is advisable to have representatives from the various trades on the advisory committee of the school. One great advantage resulting from such co-operation is the preparing of a list of apprentices in the various trades and professions. If these lists were prepared systematically it is possible to know how many new boys will be wanted each year to fill vacancies, also to prevent the preparatory training of too many boys. Attendance at the school should be a condition of apprenticeship. Co-operation also brings the local requirements to the notice of the head teacher; the work of the school should be based to a great extent upon the needs of the community.

In order to further the relationship of the school to industry it is necessary that the staff should be carefully selected and adequately paid. Instructors should be both teachers and craftsmen, well trained, and with as wide an experience as possible in their various crafts. Such instructors are not easily found; many good craftsmen refuse to accept teaching posts owing to the lack of sympathy in, and red tape methods of, educational authorities. Mere paper qualifications, which are so much prized by some educational bodies, as absolute essentials, are by no means "the last word" for an art instructor. I do not believe drawing to be of much value unless taught by somebody who believes wholeheartedly in the subject of art. What is needed is a precise, scientific and practical foundation on which the imagination and activities of the young can be built. We need not so much schools of art, as schools of practical knowledge, not so much art training, as training in workmanship, with all that the word implies. Men who can retain and teach the old traditions of craftsmanship are difficult to find. If a good staff is to maintain its efficiency the authorities must allow adequate free time to the instructors, in order to enable them to continue working in their particular craft. The best of instructors will deteriorate and become a mere walking text book if all practice ceases, and in consequence the teaching loses all vitality and freshness—two qualities most essential to art instruction. It is advisable for instructors to be engaged as "full time" instructors, and then arrange that half their time be devoted to teaching. In many instances it is only necessary to give instruction in the principles underlying a trade, leaving the practical work to the factory, but this is hardly the case in dealing with crafts covered by the curriculum of an art school. In the practical operation the skilled craftsman learns his art.

Naturally it is with the view to raising the standard of industrial art that the school is chiefly concerned, but it is of little avail if we succeed in our endeavour, only to find that there is no demand for the better production. The purchasers must be able to appreciate the better article, and in order to do this the school of art must give the general public a chance of being able to form appreciative instincts. Between the manufacturer and craftsman

on the one hand, and the general public on the other, we have a class who can either make or mar our work—the distributor. So far educational authorities have not given this powerful class any consideration or provided any means for its advancement of good taste. How many of the salesmen or women have any knowledge of the history or essential values of the things they sell? "All types of business men should be the better for knowing an outline of the history of trade or craft—the link with the past is always ennobling." The distributor acts as a strainer between his sources of supply and his customers, and he must be careful that his mesh does not strain out all the good and so lead to a low standard of production. I am aware that it is a difficult matter to successfully get hold of and arrange for this class of people. The problem is worth attacking, and the school of art authorities are the proper people to direct the attack. The young salespeople and others cannot gain a systematic and complete education in the shop or warehouse; too frequently they pick up their knowledge as best they can. It is probable that only a very small percentage of assistants have real knowledge regarding such essentials as origin, raw materials, make, texture, adulteration, dyeing, design, and quality of goods handled hourly, and discussed with the customer. In the curriculum of such courses actual drawing lessons, as usually understood, need not be included. Goethe in his day wrote:—"I do not know whose ideas should be broader than those of the true merchant." Commerce is full of romance, and it should be the duty of art—the handmaiden to romance—to help in crystallising the romantic. To me it seems obvious that any business would be improved in which its buyers, salesmen and travellers had had some training in the direction I have so briefly indicated. Some of the large firms in England and America have recognised the value of further education among their assistants, and have arranged for classes in their own buildings and in the employers' time. I hope you will agree with me and recognise the importance of the distributor in industrial affairs, and the need for some form of education.

We have also a large body of people who have no desire to draw or become producers, but who are to be the consumers of our productions. The school of art ought not to neglect these people, and courses should be arranged to meet their requirements. A series of lectures, illustrated by lantern slides, might be given, dealing with everyday matters, such as interior decoration, the treatment of walls, windows and fireplaces, good and bad fabrics for hangings, table glass, pottery, and metal work, showing the essential qualities which go towards making them good. The comparison between good and bad articles is always of interest. Co-operation between the school and the local museum is of great importance in connection with the course. The museum should be the living centre of the intellectual life of the town—a living, moving, ever-changing pageant, illustrating and illuminating every expression of art, a place of reference for the students, a guide for their practice and aims, also enabling the public to obtain

the finest possible grasp of the essential facts of life which art translates into abstract expression. Generally our museums remain the same from year to year, and the average citizen, having once visited the building, never darkens its doors again, feeling that he has nothing to lose by staying away. It may be possible for the school to have a small exhibition, or loans from other towns, always available to the public.

Too much stress should not be laid upon the fineness of old work when endeavouring to gain the interest of employers. It is difficult to interest the average employer in the best work of the past, but the present-day standard against which he is in competition will always be of value and interest. The school must prove that better work can be executed under existing conditions. With patience and tact it is possible gradually to gain the students' interest in the finest traditions of the past, but if this is attempted too early it has in many cases the effect of "putting the student off." One cannot expect any sudden rise in artistic appreciation, as with music and literature the appreciation of fine things is of gradual growth.

It is a comparatively easy matter to build up an institution on paper. Air castles too often fall, but can always be rebuilt if one so wishes, giving one a chance to change the design. In education, business methods are often ignored. On matters of this nature our frame of mind should be similar to that of a business man developing a business, and practical aims should always be kept in mind.

Three important questions arise in connection with the development of an art school, namely:—(1) How is the student to be brought to the school? (2) How is he to be kept there during the necessary period? (3) What is to become of him in the future? Firstly, a demand must be created. Many may be surprised, perhaps, at this remark, since art and beauty are usually thought of together, but there is little or no genuine desire for beauty in the world to-day. The cry that has been uttered throughout the ages, "The times are unfavourable to art," is still heard to-day. Existing in an atmosphere which is generally opposed to art, it is necessary for us to employ every method possible for the advancement of our cause.

Amongst whom can this demand for art be created? I suggest (1) Our boys and girls at school. (2) Artizans and employers whose work is connected with the school. (3) The general public.

With regard to the boys and girls a proper art course, especially in secondary schools, should help to create a demand from a few for a further art school training. Owing to the scant attention paid to art instruction in our secondary schools we miss an impressionable age. This is to be regretted, because from such schools come those who are most likely to be employers, and will direct the markets from within, and as purchasers form its control. A good art teacher will be able to pass on many keen students, while an indifferent one will probably kill all interest for further work. In order to further our aims it is essential to have the

support of the head teacher and assistant masters of the town schools. Every opportunity must be taken to bring the work of the school before the teachers, and demonstrations and lectures concerning the exhibits in the school museum and art gallery might be arranged. Loans to teachers of books, photographs, and models help to make a common interest, and circulating loans of good drawings, craftwork, lettering and paintings not only help to raise the standard of work in the schools, but suggest a further course of work at the art school.

Having created an interest, and, I hope, a desire on the part of some to take up some occupation which would involve an art training, how are we to encourage pupils to attend the school? In the first place we must offer a curriculum which shall be acknowledged by authorities and employers; secondly, by establishing small bursaries, a number of students may be enabled to attend full time. This may appear to be a very costly business, but one must consider that the larger the classes the more the Government grant is likely to be.

In dealing with our second class, the artizans, the best method of approach is through the various societies and unions of their particular trades or crafts. It is most important that the interest and support of the societies be gained, and when once the members feel that they have a definite interest in the school's welfare it is not a difficult matter to get hold of students.

The general public is a much more difficult section to get into touch with. I have already mentioned the matter of lectures. The press may be utilised in this direction; not only should the matter affect the school and its aims be written up, but general subjects which affect the town directly and indirectly, for example the historic review of memorials, designs for tombstones, town-planning, public parks, laying out of gardens, street hoardings, advertisements, street signs, and art movements in our own and other countries. It must be remembered that—

> "Art is not a matter of picture exhibitions, or a few statues dumped down in our towns, but Art is all worthy work—gardening, boot-making, building, and sometimes, perhaps, picture painting, too."

It is not merely a question of poetry and painting, but of shops, factories, house-keeping, town-building, etc. The delight in beauty comes as a reward of right work. It is the craftsman who "maintains the fabric of the world," so it is to the benefit and welfare of any community to help and maintain such a class in every possible form.

> "So is every artificer and workmaster that passeth his time by night as by day: they that cut gravings of signets, and his diligence is to make great variety, he will set his heart to preserve likeness in his portraiture, and will be wakeful to finish his work. So is the smith sitting by the anvil and considering the unwrought iron: the vapour of the fire will waste his flesh, and in the heat of the furnace will he wrestle with his work: the noise of the hammer will be ever in his ear, and his eyes are upon the pattern of the vessel; he will set his heart upon perfecting his works, and he will be wakeful to adorn them perfectly.

So is the potter sitting at his work, and turning his wheel about his feet, who is always set anxiously at his work, and all his handiwork is by number; he will fashion the clay with his arm, and will bend its strength in front of his feet; he will apply his heart to finish the glazing, and he will be wakeful to make clean the furnace. All these put their trust in their hands; and each becometh wise in his own work. Without these shall no city be inhabited, and men shall not sojourn nor walk up and down therein. They shall not be sought for in council of the people and in the assembly they shall not mount on high; they shall not sit in the seat of the judge, and they shall not understand the covenant of judgment: neither shall they declare instruction and judgment, and where parables are they shall not be found. But they will maintain the fabric of the world and in the handiwork of their craft is their prayer."—Ecclesiasticus xxxviii, 27-34.

A CURIOSITY OF MEDIAEVAL FRENCH LITERATURE.

BY

R. D. Nauta,

Professor of French, University of Cape Town.

Read July 15, 1921.

Charlemagne, an Anglo-Norman poem of the 12th Century, etc. London and Paris. Editio princeps Francisque Michel, 1836.

Le Pèlerinage de Charlemagne, Dr. E. Koschwitz, Leipzig, 1895.

The most remarkable and at the same time the most original production of the early popular French literature is the epic. In the classical form of Chansons de geste, i.e., songs of deeds of derring do (gesta), it accomplished more for the glory of mediaeval France than any other form of literary composition. Primarily the chansons de geste were composed for recitation by the jongleurs or minstrels, who also sang them to a very simple melody, accompanied by the vielle. The trouvère or poet rarely sang his own compositions, but, as a rule, sold them to the professional jongleur. Originally these epic songs were sung by the jongleur as the warriors marched to battle; but later on they became a pastime for the lords at their meals and festivals. Taking their tone from the audiences, before whom they were sung in the castle halls of the feudal nobility, the chansons de geste dealt almost invariably with incidents of war and battle. Their central hero is Charlemagne, in whose majestic figure their spirit finds its nobled embodiment. He stands for the whole of the Carolingian race welded into one dominant character of epic literature, as the type of the imperial ruler. He is the conqueror of the Saracens and the Saxons, the revered protector of the church and the clergy, the supporter of justice, the terror of the great, the comfort of the poor. The noblest portrait of Charlemagne is set forth in the first and greatest of the chansons de geste: the "Chanson de Roland," which, after a long course of development, dates in its

final form from the second half of the 11th Century. The curious and amusing epic, which forms the present subject, belongs to the same period. Its hero is also Charlemagne, but *quantum mutatus ab illo Carolo* that moves before us in the Chanson de Roland!

It was in those very days, which saw the birth, in France, of the "Chanson de Roland," that a certain jongleur appeared before an audience of villagers and citizens, who, between St. Denis and Paris, were celebrating the annual feast of the sacred relics, the famous so-called Lendit, which, according to the clergy, had been instituted by Charlemagne at Aix-la-Chapelle, but which Charles the Bold, his grandson, had transferred to the latter locality, along with the relics (Gaston Paris). The monks of the ancient abbey, burning with holy zeal, have just been exhibiting their marvellous treasures before the pious pilgrims: one of the nails of the holy cross, the crown of thorns of our Saviour, and many more. A goodly sum has been collected for the treasury of the Sanctuary. But Christian worship and devotion have now had their day with the pilgrims, and a craving for merriment makes itself felt. The mellow tones of the instruments of minstrels and jongleurs are heard, the hour of wine and wassail has arrived, and cheerfully the crowd disperses to participate in the various amusements which are lavishly held out to them on all sides. The jongleur, dressed in a long, dark raiment, his vielle hitched to his belt, climbs on to a bench, ready to recite and sing. It appears that, unlike his colleagues, the clergy do not consider him to be a worker of iniquity and an outcast. The monks of St. Denis may rather look upon him as a collaborator in their holy task. For, in the poem that he is going to recite, the self-same relics, which just now they exhibited before the crowd, will be glorified and sung; holy relics, which according to the universally believed legend, Charlemagne brought home from the Holy Land. It is the poem which, on its publication, was given by its editor the title of *Pèlerinage de Charlemagne*. After a prelude on the vielle, which gives the audience an opportunity to quiet down and rise to the occasion, the jongleur starts off:—Once upon a day King Charles had gone to church at St. Denis. He had dressed in full royal array: from his shoulders floated down the purple velvet, his crown was on his head, his sword of state was hanging from his belt. When, after reverently making the sign of the cross, he had been for a while strutting to and fro in front of his courtiers, immensely pleased with himself and with his trappings, he stepped outside, took his queen by the hand, led her to a spreading olive tree, and towering before her in all his glory, he said: "Tell me, mylady, whether you did ever see in your life a more handsome and perfect king than me, and whether you can imagine any prince, whom sceptre, crown, and sword suit so passing well?" "Surely, mylord, I can," answers the queen, with a quizzical glance at her vainglorious spouse, "I know one who leaves you far behind in gracefulness of form and princely splendour." "His name!" shouts the king, who has got pallid with amazement and fury. "His name! I want to see this paragon, and if you lie I swear it

will be your death!" The poor queen now feels unspeakably sorry for her thoughtless sally. Bathed in tears, she flings herself down at the emperor's feet. Truly, it was but a harmless joke! God Almighty may be her judge! She is prepared to hurl herself down from the highest steeple in the city to prove her innocence. It is all in vain. The emperor tramples the earth for sheer fury. "His name! His name, I say," thus he bellows, "or I shall kill you!" Maddened with fear, the poor queen casts about for a name, seizes the first that she can think of, and replies in agony: "Hugo, the Emperor of Constantinopel." That is enough. He accepts the challenge. Charles will pit himself against that much vaunted Hugo! His intention had been, for some time, to go on a pilgrimage to the Holy Land and to worship on the tomb of the Lord. So much the greater the urgency not to tarry any longer. From Jerusalem to Paris the road lies via Constantinopel!

Thirteen strong mules are saddled and harnessed forthwith. Unarmed, with only a pilgrim's mantle, scrip and staff, Charlemagne and his twelve paladins start on their journey, and the queen, who is weeping bitterly, remains alone in the empty, vacant church.

The party arrive at Jerusalem and visit the glorious marble church, where Christ himself has sung at mass and eaten the last supper with his disciples. The twelve stalls of the apostles are still there; and next to these stands the thirteenth, closed up and sealed. Without hesitation and fearless, fully conscious of his dignity, the Frankish emperor breaks lock and seals and sits down on the sacred throne, beckoning to the peers to follow his example. A Jew, who happens to enter the church when all of them are seated, stands dumbfounded at the sight, and is overcome to such an extent that, shivering with awe, he has himself baptised on the spot. The grey-haired patriarch now arrives and kneels down in front of the impressive stranger. "You would like to know who I am," says the king to the priest. "My name is Charles; my cradle stood in France; twelve kings I conquered and now I am on my way to visit the thirteenth, whom I want to crush in the same manner." The worthy patriarch overwhelms his guests with honours, and at Charles' request distributes among them as many holy relics as he can gather together: the arm on which Simeon carried the infant Jesus, body clothes of the Holy Virgin, a nail from the true cross, a few hairs from St. Peter's beard, Lazarus' head, and many others. The prelate requires no thanks; if only the emperor promises him to make war on the infidels in Spain he will hold himself amply rewarded. Four months the pilgrims spend in the Holy City. Then they depart for Jericho, there to gather palm branches. From Jericho they start for Constantinopel; the magic power of the holy relics which they are carrying enables them to cross dryshod all rivers, creeks, and lakes. The pearl of the east erelong looms in the distance; they arrive while it is shining in its utmost glory. The Frankish knights are all but dazzled by the splendour and magnificence that now beams upon them. At the very precincts they cross the most lovely forests of pine and

laurel trees, in whose shade well-night twenty thousand knights are partly absorbed in the noble game of chess, and partly occupied at disporting themselves in the neighbouring copses, with three thousand graceful maidens. However, Charles does not forget the aim of his journey. He enquires after King Hugo the Strong. They point out to him a certain neighbouring field, and wending his way thither he finds the oriental prince enthroned on a palankeen between two fine mules. In propria persona he is driving a sterling gold ploughshare through the furrows. William of Orange, one of Charles's companions, who knows but too well how scarce money is in France, can barely refrain from shivering to pieces this golden plough in order to sell the fragments. The king, fully aware of the numberless rapscallions who infest the highroads of his domains at home, is amazed to see that this oriental potentate dare leave such a priceless gem behind unguarded; and he secretly envies a prince, who asserts that he is reigning over a country, where there are no thieves.

In the meantime Hugo bids his guests be welcome, and takes them to his palace. Here everything is shining with gold and silver. The big hall especially is a consummate masterpiece of architectural art. In the centre there is a huge silver-coated column; and along the walls all round there are a hundred pillars. Each of these pillars shows on either of its sides the bronze statue of a youth, holding an ivory horn to his mouth. As soon as the wind rises the hall starts turning round, the central column being its pivot; the bronze youths look at each other and wind their horns, discoursing clear, sweet music like the angels' song in Paradise. Charles is stunned with amazement and admiration, and comes to the conclusion that his French castles are not worth a rap. But suddenly a terrible thunderstorm bursts over the city, the wind rises, and soon a hurricane is blowing. A marvellous scene now follows. The hall is spinning round, spinning more and more quickly. The king and his paladins lose their foothold and are hurled against the walls, and full of anxiety, maddened and giddy, they clamour that this awkward miracle may be stopped. Luckily the wind soon abates, and they are invited to the banqueting hall, where they sit down at tables bending under the weight of the most delightful food: wild boars' heads, cranes, and devilled peacocks.

After the meal Hugo takes his guests to another hall, in whose centre a huge carbuncle flashes and glitters with almost more than solar lustre, and where thirteen luxurious couches and a number of wine tankards are ready for them. After their host's departure Charles believes that he is alone with his vassals; but behind a marble staircase the artful and designing Oriental has stationed an eavesdropper, a spy, whose duty it will be to overhear the conversations of the strangers. And, forsooth, this listener is going to overhear marvellous things! Charlemagne proposes to follow the time-honoured French custom of telling tales of stunning brag and wondrous derring do, the posset going round freely all the time. They called this pastime gaber. Of course the proposal

meets with loud applause, and the bragging is started. The king takes the lead and states that he will undertake to cleave from head to foot King Hugo's most gallant knight, mounted in full and shining armour on his steel-caparisoned charger. He will not only cut in two the rider but the horse as well; and give such momentum to his sword that after the blow has been struck it will still sink three feet into the ground below. Roland, the hero of the "Chanson de Roland," now takes the floor and says that he will take his stand at three miles from the city and wind his oliphant, his ivory horn, with such an irresistible blast that the gates of the town will be blown open and King Hugo set spinning with such velocity that the friction of the air will set his moustache on fire. Olivier, Roland's bosom friend, who while at dinner had got over head and ears under the spell of the beauty of King Hugo's charming daughter, now rises to his feet and tells them, right wantonly, that with this Oriental belle he intends consummating such incredible feats of love that even Hercules would have recoiled at the mere thought and mention of them. Bishop Turpin now speaks, and promises to undertake the bold equestrian feat of leaping successively on the back of three racehorses while in full career; in the meantime he will be juggling with four balls. William of Orange is certainly not behindhand when now he says that he will hurl, single-handed, against the palace wall a stone ball too heavy to be carried by thirty ordinary men. The impact will cause forty fathoms of the wall to crumble into rubble. Then Bérenger stands up and says that he intends jumping down from the highest minaret, on the point of a thousand swords: the swords will bend like reeds and do him no harm. Aïmer now follows and says that he will don a hat that shall render him invisible (this reminds us of the "Jarnkappe" which plays such a part in the German mediaeval epic), and make it easy for him, when the Emperor Hugo is sitting at table, to eat all the fish on his plate and drain all the wine from his goblet. Bernard de Bresban will make the river overflow its banks and flood the country, so that King Hugo shall have to look for refuge on the top of the highest steeple in the city. Génin will put two small coins on the top of a spire; he will take up his stand one mile from its foot, and throw a knife at the coins; the uppermost coin shall not budge, the other one will fall down and he will run so fast that he catches it before it strikes the earth!

And thus one "gab" follows the other till the braggarts get tired and go to bed. The poor eavesdropper, who after the king's "gab" at the beginning had already come to the conclusion: "Que fols fist li reis Hugue, quant vos prestat ostel" was in an agony of fear all the time he had been squatting in his hiding place. When the frightful heroes are snoring he hurriedly sneaks away to tell his master about the appalling crowd to whom he has given hospitality.

Hugo the Strong waxes wild with anger. He understands that all this boasting is sheer contempt and impudent derision. When the next morning the Emperor Charles leaves church Hugo

walks up to him in high dudgeon, upbraids him for his vile conduct, and threatens to kill all his guests if the "gabs" are not carried into execution without delay. The Frankish prince stands aghast. The occurrence should not be taken so seriously at all. But King Hugo seems not to be possessed of any sense of humour. "My Lord," says Charles to their host, "be your Majesty pleased not take it amiss in us, but it is the custom in Paris and at Chartres to emulate and outvie one another in bravado and heroics, whenever one is comfortably stretched on one's couch after generous libations. Indeed, your claret was too good not to keep up this tradition over here!" But the kind words of his guest were unable to soften the heart of the dignified and solemn Oriental. The "gabs" were to be carried into execution forthwith; if not the fate of the pilgrims was sealed.

Great are the embarrassment and the consternation among Charlemagne and his companions. They do not carry arms, for the heroes have travelled to these remote parts as pilgrims and not as warriors. Nothing remains for them but to implore help from Heaven. Luckily their fervent prayers are heard: an angel descends on earth with a message of comfort: the heroes will be enabled to make their marvellous feats of strength materialise. But with warning finger uplifted the messenger from Heaven says that this must be the last of their careless bragging at other people's cost. Even Frenchmen ought not to dare indulge in too much folly.

Full of good cheer and courage, the knights return to their angry host and inform him that they are prepared to accede to his request. Out of the thirteen "gabs" he is allowed a free choice, and the wonderful display will start at once. The Emperor Hugo shows little delicacy in his choice, when he appears to be prepared to give up his lovely daughter to Olivier's brutal caresses. The latter, however, remains true to the character and traditions of his nation, in never losing sight of gentle courtesy. After Olivier, William of Orange enters the lists with his granite ball, and, in fact, forty fathoms of wall are knocked down without apparent difficulty. Then Bernard floods the city, and the Emperor Hugo, who has taken shelter in the highest tower, beseeches his mighty guest to stem the ever-rising waters. Charles, quietly perched with his twelve peers in the top of a tall pine tree, offers up a prayer, which causes the flood to subside almost at once.

"Would you like to have more of it?" Charles asks the trembling monarch in bantering tones.

"Not this week, thanks," replies Hugo the Strong, "for if all your 'gabs' come off like these there would be nothing but weeping for me and gnashing of teeth. Rather allow me graciously to do homage to you, and henceforward to receive my empire from you as my liegelord." Charles cannot but accept so generous an offer; and in order to give additional lustre to the event he proposes that the two princes shall array themselves in their full Court dress and regalia, and parade together in the gardens. And lo! when the two kings appear in their golden crowns all the paladins look with

wonder and admiration at their western lord; for if it be true that either of them does ample credit and honour to his crown it is clear now that Charles is fully one foot and three inches taller than his Oriental host. The French knights are delighted, and each of them says to himself: "How foolish it was of the queen to speak as she did! Experience teaches again and again: we Frenchmen cannot visit a country but we carry either a victory or a prize."

After this happy issue they all enter the church, and Bishop Turpin officiates at mass. A glorious banquet follows this ceremony; the most delightful wines are poured out into the silver goblets, a profusion of the most delicious game and of peacocks is piled upon the dishes. When all the guests are satisfied the saddles are placed on the backs of the sturdy mules and the French knights get themselves in readiness for the journey back. The leave-taking is as cordial as it is cheerful; only one incident partly spoils it. Hugo's poor daughter, desperately in love with Olivier, comes running along, seizes the stalwart knight by his mustachios, and beseeches him to take her with him to France. But the handsome swain only bids the poor girl to keep green the memory of their love, and laughing merrily proceeds alongside of his lord.

After a happy journey they arrive in the good city of Paris. Without delay Charles proceeds to St. Denis, and after reverently depositing the most valuable of his holy relics on the altar of the church he unexpectedly finds the queen all of a tremble and lying on her knees at his feet in the chancel. She implores his forgiveness for her thoughtless behaviour and her foolish doubts. Graciously the king holds out to her the hand of forgiveness, and bids her rise to her feet for the sake of the Holy Sepulchre, where it has been his privilege to worship, and soon after the old offence was forgotten and condoned. Here the poem ends.

It may be taken for granted that after reciting the nine hundred alexandrines, the contents of which we have but very roughly outlined in the summary above, the jongleur was rewarded with a thundering applause. Maybe he was himself the author of the poem; the comic flavour with which it is redolent throughout is indeed much more suggestive of the droll buffoonery of a jongleur, whose field of action is chiefly the city and country fairs than of the severe solemnity of the trouvère, who only sang in castle halls before the nobility, and who would surely have scorned so fast and loose a treatment of epic matter. The dignified trouvère, fond as he was of long-winded poetry, full of repetitions and parallelisms and digressions, would moreover not have contented himself with the production of an epic of no more than a paltry 900 verses; and it is doubtful also whether he would have stooped to abandon the usual rhythm of decasyllabic verse and to adopt the alexandrine instead. Whosoever the maker may have been, he must have been a poet of the people, a poet fully conversant with the popular taste and inclinations. At a time when the stately, serious epic celebrated its greatest triumphs, the poet of Charlemagne's Pilgrimage knew how to sound a note which, while stirring the people's religious sense, tickled at the same time

their love of genial laughter. We may rest secure that it was by no means his intention to compose a parody of the Carolingian epic. His reverence for the emperor-king, the favourite of heaven, is equal in its intensity to that of the most fervent and solemn worshipper of Charlemagne. The scene, for instance, in which he introduces Charles and his twelve paladins sitting down in the sacred stalls of the church at Jerusalem must, in all fairness, be reckoned among the most arresting fragments in the entire range of French epic poetry. His veneration for the holy relics is second to none, and on a par with that of the most pious visitors of the abbey of St. Denis. The great king strutting up and down, like a prinking peacock, in front of his courtiers, was probably not so ridiculous a performance in those days as it would appear to us at present. Even in the dignified "Chanson de Roland" it is one of Charlemagne's fads to dress in full array, his "barbe fleurie" flowing majestically over his shining coat of mail, and, mounted on his charger, to trot to and fro before his admiring court. No, the author does not want to scoff; he wants to make his audience laugh, and with complacency he expatiates on the funny episodes of his tale. He wishes to blend the serious and the jocose, the respectful and the laughable, and in doing so he stands decidedly apart from his colleagues. He has entwined and wrought into one two kinds of epic subject matter of different extraction. As a matter of fact there was a legend abroad about a pilgrimage to the Holy Land, which Charlemagne was believed to have undertaken at some time or another, a legend indeed which had no other foundation than the really keen interest which the historical Charles had always taken in the Christians of Jerusalem, and which he had shown by building for them a hospital and a church both sacred to the Holy Virgin. On the other hand there was a kind of fairy tale rife in those days, which later on was discovered to be also incorporated in Arabian Nights, in the Breton romances of King Arthur, and even in Norse mythology; and according to which a king, or a god, whose superiority over all the other mortals some unlucky earthling ventures to doubt and gainsay, undertakes a long journey in order to bid defiance and fling the gauntlet down to this hypothetical rival.

Possibly the episode of the "gabs" was partly borrowed from some similar source and partly of the poet's own invention. In fact, to collect data for these "gabs" he had only to look about in his own surroundings, where he was sure to find plenty of models. For, does not he make Charles say to King Hugo: "Sire, it is a time-honoured custom in Paris and at Chartres to brag and bluster in this way over one's cups?" We shall not be far wrong in taking it for granted that the poem was a huge success in its time. We feel so in spite of the fact that what has been preserved of it is not its original form. Of all the copies which were undoubtedly made of it in Paris from time to time not one is left. Luckily, however, there was an Englishman among the pilgrims to the famous Lendit, who was wealthy enough to buy a copy for himself. He took it home and had it copied there. His Paris

manuscript is no longer in existence; but the copy, as he had it made in England, is in the collections of the British Museum. (16 E. viii.)

Unfortuately his scribe had a very imperfect knowledge of French, and so he fitted the poem out in the garment of his own Anglo-Norman tongue. Moreover, this copy is defaced by numerous gaps, mistakes, and inaccuracies, which have given considerable trouble to the editors whom these blemishes compelled to all sorts of guesses and conjectures, which, though ingenious, here and there, will have to remain guesses and conjectures. However, as not a single specimen of the original French poem is extant this manuscript, faulty and imperfect as it is, is nevertheless of the greatest value.

The poem of Charles' pilgrimage is a genuine product of French national soil and exactly the kind of tale to be recited before an animated and merry popular crowd. The antithesis between the dazzling luxury and wealth of the East and the nimble-witted, sparkling chaff of the Western visitors, hallmark the poem as being purely French. The mixture of respect and familiarity with which the author treats his hero is equally national. He pictures him as if he were a god, enthroned on the sacred seat of the lord, and makes him stand awkward and perplexed like a naughty urchin, before the Emperor Hugo. He hails him as the worthy bearer of miracle-working relics, and glorifies him as the boon companion of a company of merry topers. He allows him the honour of an angel's visit, and makes the envoy of heaven begin his message with a scolding. In short, he is absolutely infatuated with his hero and at the same time pokes fun at him and laughs at him. Such infatuation, knit up with irreverence, such familiar intercourse, which does not do the slightest harm to true regard, although it sometimes may impair its gravity, is another characteristic of French mentality. In France itself this popular theme has undergone all kinds of refacimenti. When, later on, the exploits of Galien, the son of King Hugo's unfortunate daughter Jacqueline and her faithless lover, Olivier, were recorded in more recent epics, the tale of Charles' pilgrimage to Jerusalem and Constantinopel was recast and connected with them. As a matter of course, the "gabs" remained the favourite episode of the poem, but the golden plough was not forgotten either. It lasted long, indeed, before the popularity of Charles' pilgrimage and Olivier's love became exhausted. Even in the last quarter of the Eighteenth Century we find an echo of these two old beloved themes. First La Chaussée devoted his efforts to a poetical version of the ancient but not yet worn-out subject; and soon after, Marie Joseph Chénier, the famous André's brother, attempted the same. La Chaussée's verses are none of the best, and Olivier's adventure with Jacqueline constitutes the bulk of the work (Le Roy Huyon, Conte). Chénier's decasyllabic lines treat with much gracefulness and delicacy the scene of the "gabs." He represents King Hugo as a Mohamedan, and makes Jacqueline's conversion to Christianity the price of Olivier's exploit. (Les Miracles, Conte.)

Thus the ancient epic lived on and on, altering and renovating its form, and modifying its contents according to the ambient taste. It left untouched what constituted its pristine originality, and kept the efficiency by which it permanently fascinated and amused such audiences as were not too exacting unimpaired. The student of literature bent on collecting and classifying among the productions of human genius those which have not suffered too badly from the caprices and vagaries of fashion, and which could naturally not suffer much from these, because they did not wish to please any other taste but the simple, conservative, and stable taste of the people, will be quite prepared to award if not a first prize, then certainly a second, to the "Pèlerinage de Charlemagne."

ARCHIVAL PROBLEMS IN SOUTH AFRICA.

BY

C. Graham Botha,

Keeper of the Archives, Cape Town.

Read July 13, 1921.

In recent years the matter of archives, their preservation and accessibility, has received some attention. But this is only the beginning of the interest which should be taken in our national records. They form the chief monuments of our history, and reflect with remarkable fidelity conditions throughout the country at various periods. In South Africa the pre-Union records are centralised in the capitals of the four Provinces—that is, those of the Central Government of the former colonies are still to be found in Cape Town, Pretoria, Pietermaritzburg and Bloemfontein respectively. In course of time some of these will have an historical value, and it will be necessary to preserve them for the historical scholar.

Those who have worked in the big archives in Europe will know how much the science of archives has developed. There archivism is a profession, and the man who desires to become a member of the archive staff must show proof of his qualification. In some countries he must undergo several years of training of a high standard; for instance, in France he must produce a diploma from the Ecole de Chartes, and in Holland from the recently established School of Archives. In Germany and Belgium there is also a regular course to be gone through.

In South Africa we are at the beginning of our archival problems, and we have the great advantage to begin, as it were, with a clean sheet, and take our model, not from any particular country, but the best from each country, and adapt it, as far as practicable, to our own needs.

One of the many matters which requires our early attention is that of having some legislation which will provide for the trans-

ference to the archives of the public records which are no more of administrative value. The more important duties which fall upon those entrusted with the management of records is that of their safe custody, better preservation and convenient use. The great growth of Government business, the expansion of the departments, and the creation of new ones since Union, has lead to a rapid accumulation of records. Many of these will, in due course, have an historical value, and as they become non-current, should be transferred periodically to an archive repository. Machinery should therefore be provided for the systematic and regular transmission of such papers to recognised archive offices.

The next point that should receive attention is the safe custody of such papers. They should be placed in a building set apart exclusively for the preservation of the national records. Too often the "dead" papers of a department are scattered through the department's building. They are to be found in the basement, in the corridors and in the rooms occupied by the clerical staff. In order to save them from irreparable loss through fire, damp and dust they should be kept in properly constructed buildings with plenty of light, air and ventilation. The great enemies of documents are fire, damp, dust, dirt, and it may seem strange to some, the autograph and stamp collector. The archive building should not be attached to any other building, and should allow for future enlargement, a matter which is bound to occur at some time or other. For a model building to house the national and provincial records we can take some of those found in the European centres, as at The Hague, Rotterdam, Vienna, Dresden.

When our records have been properly housed we must next look to the problem of making them accessible for the scholar who desires to use them for historical, economic and scientific purposes. The right of the student to make use of them is now recognised by all countries. After the archives have been arranged and classified, it is necessary to have lists, inventories and catalogues prepared, so that the enquirer may know what the collections contain. This is a very important matter in the system of archive keeping and, unless it is done systematically and scientifically, will only lead to confusion. This work has two objects in view: one as a precaution against loss, and the other as a source of information to the archivist and student. At a later stage the work is expanded and particular series are dealt with in more detail; for example, calendars are prepared.

To carry out the very important work of classifying and cataloguing will require not only an adequate staff, but also an efficient one. To perform the higher class of work it will be necessary to have men with some special qualification. As I remarked above, in Europe only men who have undergone a certain training can look to admission to the higher posts in an archive office. It must be borne in mind that an archive office is not merely an administrative department, nor are the members of the

staff merely clerical assistants. To a great extent it is a scientific institution. It is the preparation ground of the material for the historical scholar. Conditions in South Africa are somewhat different from what they are in Europe, where archivism is a profession, and the preparation of a number of students every year to fill posts in the various archives is justifiable. But that does not lessen the important necessity of having some system by which the future archivist in South Africa should have some knowledge of the work that lies before him.

When an archive collection has been properly housed and inventoried by a competent staff, then the student claims our attention. What are his rights? What facilities should he have, All civilised countries have recognised the right of their citizens to use the archives under certain restrictions. After the Government's interests have been safeguarded and proper regulations drawn up for the use of the records, every facility should be granted to the bona-fide research worker. Up to what date should public records be open for inspection, and should any restrictions be placed on those that are available? These are important questions. All countries have a limitation upon the accessibility of their records, and rightly so. Some countries allow greater latitude than others in this respect. I am of opinion that as great latitude as possible should be allowed to historical students. It would serve no useful purpose to suppress records of historical value, or to conceal documentary evidence. It would be well that, when a document has reached a certain age from the date of its making, it should be open for inspection. In France, except in particular instances, where special reservations have been made, documents may be communicated to any French citizen after fifty years have elapsed.

While the use of the records may be accorded to the bona-fide student, there yet remains the serious problem of the actual handling of the papers, for which definite and strict regulations must be drawn up. Experience of the European archives has shown the necessity of this, and every country has some rules to which the student has to adhere or forfeit the privilege given him of searching the papers. Rules are laid down relating to the number of documents allowed to a worker at one time, to the making of tracings or photographs, to the removal of any papers from the Search Room, to the removal of any volumes from the shelves, and the entering of the repository in which the archives are kept by any of the public except when accompanied by one of the archive's staff, and to the actual handling of the papers. All these and other restrictions as to what the reader can and must do are matters of the utmost importance.

But with these few facts before us I trust that you will perceive that the subject of the development of our archives in South Africa is one that will require our very serious attention. If we in this country fully realise and appreciate the great value and wealth of our authentic records, then we must acknowledge that it is our bounden duty to endeavour as far as our resources

permit to develop them on a proper and sound basis. The subject of archives, their preservation, use and administration in this country has been neglected too long. Why should we not awaken from our slumber and push forward in this important matter and rise to the occasion, so that we may come into line with other nations? There is no obvious reason why we should not do so.

INDEX OF AUTHORS.

The complete list of papers read at the Durban meeting will be found on pp. 140-142. A few of the papers listed there are not printed in this Journal.

INDEX OF SUBJECTS.

LIST OF MEMBERS

OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

1st JULY, 1922.

Members are requested to notify the Assistant General Secretary (P.O. Box 6894, Johannesburg), of any change in address or title, as soon as possible.

Year of Election.

1902. A-Ababrelton, Robert, F.R.G.S., F.R.E.S., F.S.S., Royal Colonial Institute, Northumberland Avenue, London, W.C.
1918. Aberdeen, James, 5, White's Road, Bloemfontein.
1916. Abrahams, Abraham Mark, Jewish Government School, End Street, Johannesburg.
1902. Aburrow, Charles, M.I.C.E., M.S.A., P.O. Box 534, Johannesburg.
1905. Adamson, John E., M.A., D.Lit., Education Department, Pretoria.
1918. Aders, Walter Mansfield, Ph.D., Zanzibar Government, Zanzibar.
1917. Affleck, Arthur, A.S.A.A., P.O. Box 1032, Johannesburg.
1904. Aiken, Alexander, P.O. Box 2636, Johannesburg.
1921. Aitken, R.D., M.Sc., Natal University College, Maritzburg.
1915. Akerman, Conrad, M.A., M.B., B.C., Conethmoar, Alexandra Road, Maritzburg.
1905. Albu, Sir George, P.O. Box 1242, Johannesburg.
1921. Alexander, D. B. W., Borough Engineer's Office, Durban.
1921. Amm, Ross, P.O. Box 2166, Johannesburg.
1916. Anderson, Peter M., B.Sc., P.O. Box 1156, Johannesburg.
1910. Anderson, Dr. A. Jasper, M.A., M.B., D.P.H., Dorp Street, Capetown.
1921. Anderson, L. R. D., P.O. Box 909, Durban, Natal.
1920. Andrew, J. L., B.A., King Edward VII. School, Johannesburg.
1921. Andrews, Professor W. H., D.Sc., Transvaal University College, Pretoria.
1918. Anderssen, Mark, P.O. Box 4066, Johannesburg.
1902. Andrews, G. S. Burt, M.I.C.E., M.I.Mech.E., M.S.A., P.O. Box 1049, Johannesburg.
1917. Andrews, George J., P.O. Box 27, Jeppes, Johannesburg.
1921. Appleton, T. W., Box 909, Durban.
1921. Archibald, Alexander, 51, Van der Merwe Street, Johannesburg.
1920. Ardley, W. G., P.O. Box 2303, Johannesburg.
1919. Arndt, Professor W. F. C., Ph.D., 3, Goddard Street, Bloemfontein.
1920. Armstrong, Miss E. H., 12, Walter Mansions, Eloff Street, Johannesburg.
1920. Arnold, G., D.Sc., Rhodesia Museum, Bulawayo.
1921. Ash, Arthur S., Cullinan Buildings, Johannesburg.
1916. Ashkanazy, A. W., Castle Mansions, Eloff Street, Johannesburg.

1919. Aslaksen, Adolf Anton Bernhard, M.I.C.E., c/o W. Brooker, Zwartkops, Port Elizabeth, Cape Province.
1904. Auret, A. A., P.O. Box 838, Johannesburg.
1916. Austin, Kenneth, M.Am.I.M.E., P.O. Box 4305, Johannesburg.

1921. Backenstoe, W. A., M.D., Izingolweni, Natal.
1906. Bailey, Sir Abe, Bart., P.O. Box 50, Johannesburg.
1922. Bailey, Miss E. J., P.O. Box 1248, Johannesburg.
1918. Baker, Norman Thomas, P.O. Box 3958, Johannesburg.
1919. Baker, Rev. C. Buckingham, 19, Glenshiel Road, Eltham, London, S.E.
1920. Balfour, J. A., M.I.C.E., P.O. Box 442, Lourenço Marques.
1920. Ball, Miss D., 737, Musgrave Road, Durban.
1916. Ball, Mrs. Olivia Wolfenden, Monte Cristo, Town Hill, Maritzburg.
1919. Ballantine, Major Robert, Keiskama Hoek, Kingwilliamstown, Cape Province.
1903. Balmforth, Rev. Ramsden, "Shirley," 6, Stephen Street, Capetown.
1914. Bancroft, Alfred Ernest, M.A., M.Sc., South African College High School, Capetown.
1919. Barnes, Frederic Crouch, P.O. Box 29, Kingwilliamstown, Cape Province.
1922. Barnett, Arthur, Steytler's Buildings, Loveday Street, Johannesburg.
1922. Barradas, Dr. A., Liceu, Lourenço Marques.
1911. Barratt, Gaston Frederick Sharpe, Bembezaan, Queque, Southern Rhodesia.
1911. Barratt, Rowland Lorraine, Bembazaan, Queque, Southern Rhodesia.
1905. Basto, H.E. Alberto Celestine Ferreira Pinto, 95, Rua Luiz-de-Camoez, Lisbon, Portugal.
1922. Battaerd, Professor P. J. T. A., M.D., University of Stellenbosch, C.P.
1903. Baxter, William, M.A., South African College High School, Capetown.
1902. Beattie, Sir John Carruthers, D.Sc., F.R.S.E., Principal of University of Capetown.
1922. Beattie, W. A., 24, Jager Street, Hillbrow, Johannesburg.
1915. Bedford, Gerald Augustus Harold, F.E.S., Veterinary Research Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1913. Beerstecher, Leonard, P.O. Box 2888, Johannesburg.
1922. Berry, Dr. A. W., P.O. Box 288, Johannesburg.
1916. Bertram, T., 134, Market Street, Benoni, Transvaal.
1922. Beveridge, G. O., P.O. Box 2827, Johannesburg.
1916. Bertram, Reginald Hermanus, P.O. Box 3518, Johannesburg.
1916. Bews, John William, M.A., D.Sc., Professor of Botany, Natal University College, P.O. Box 375, Maritzburg.
1920. Beyer, Rev. G., P.O. Mapela, via Potgietersrust.
1918. Bigalke, Rudolph, M.A., Experimental Farm, Glen, O.F.S.
1922. Bird, M. C., P.O. Box 3811, Johannesburg.
1920. Bishop, Rev. H. L., P.O. Box 724, Lourenço Marques.
1919. Bissaker, John, P.O. Box 118, East London.
1905. Blackshaw, George N., O.B.E., B.Sc., F.I.C., Department of Agriculture, Salisbury, Rhodesia.
1915. Blundell, Frederick Moss, 308, Orient Street, Arcadia, Pretoria.
1922. Bodkin, H. A., Bloemfontein.
1906. Bohle, Hermann, M.I.E.E., Corporation Professor of Electrotechnics, University of Capetown.
1905. Bolus, Arthur Charles, 20, Steytler's Buildings, P.O. Box 232, Johannesburg.
1905. Bolus, Mrs. F., B.A., Sunning Hill, Eyton Road, Claremont, Capetown.
1917. Bosman, Andrew Murray, B.Sc.Agr., B.S., Professor of Agriculture, Transvaal University College, Pretoria.

1913. Botelho, Captain Joao Baotista, Chief Veterinary Officer, Department of Agriculture, P.O. Box 225, Lourenço Marques.
1919. Botha, Colin Graham, Box 6, Capetown.
1921. Boustred, W. F., P.O. Box 1525, Johannesburg.
1920. Botting, F., 21, Goldreich Street, Hillbrow, Johannesburg.
1916. Bottomley, Miss Averil Maud, B.A., P.O. Box 1294, Pretoria.
1921. Bowles, E., Magistrate's Office, Johannesburg.
1913. Bracht, Oscar, P.O. Box 134, Port Elizabeth, C.P.
1915. Breijer, Hermann Gottfried, Ph.D., Director of the Transvaal Museum, P.O. Box 413, Pretoria.
1920. Briggs, Miss E. E., "Friedura," Victoria Park, Parktown, Johannesburg.
1910. Brill, J., Litt.D., L.H.D., Ph.Th.M., Lorothwana, 65, Park Road, Bloemfontein.
1914. Brinton, Arthur Green, F.R.C.S., L.R.C.P., F.R.S.M., P.O. Box 4397, Johannesburg.
1910. Britten, Gilbert Frederick, B.A., Government Chemical Laboratory, Capetown.
1918. Britten, Miss Lilian Louise, B.A., Rhodes' University College, Grahamstown, Cape Province.
1903. Brown, Alexander, M.A., B.Sc., F.R.S.E., Professor of Applied Mathematics, University of Capetown.
1914. Brown, Rev. Holman, Selukwe, Rhodesia.
1907. Brown, William Bridgman, M.A., Penryn, Cyphergat, C.P.
1909. Brownlee, John Innes, M.B., C.M., Tembani, Alexander Road, Kingwilliamstown, Cape Province.
1912. Brummer, Rev. Professor N. J., M.A., B.D., University of Stellenbosch, Cape Province.
1919. Bryson, James Watson, P.O. Box 134, Kingwilliamstown, C.P.
1902. Buchan, James, Assistant Resident Engineer, Rhodes' Building, Bulawayo, Rhodesia.
1921. Buchanan, W. J., P.O. Box 3633, Johannesburg.
1917. Buller Arthur Cheverton, Dwarsriviers Hoek, Stellenbosch, Cape Province.
1920. Burton, D. M., African Realty Trust, Simmond's Street, Johannesburg.
1903. Burtt-Davy, Joseph, F.L.S., F.R.G.S., "Inglesby," Storey's Way, Cambridge, England.
1916. Burtt-Davy, Mrs. J., "Inglesby," Storey's Way, Cambridge, England.

1919. Caink, Thomas George, M.Inst.M. & C.I.E., M.R.San.I., Borough Engineer, Kingwilliamstown, Cape Province.
1903. Caldecott, W. A., B.A., D.Sc., F.C.S., P.O. Box 67, Johannesburg.
1919. Caldwell, W., 108, Louis Botha Avenue, Parktown, Johannesburg.
1922. Cameron, A. S., 10, Rissik Street, Johannesburg.
1917. Campbell, Colin M., Mount Edgecombe, Durban, Natal.
1916. Campbell, Edmund, P.O. Box 688, Durban, Natal.
1921. Campbell, James Donald, P.O. Box 1814, Johannesburg.
1916. Campbell, Samuel George, M.D., M.Ch., F.R.C.S.E., M.R.C.S., D.P.H., 28, Musgrave Road, Durban, Natal.
1919. Canard, Nathan, P.O. Box 313, Capetown.
1908. Carlson, K.A., Forestry Division, Department of Agriculture, P.O. Box 535, Pretoria.
1919. Carrington, John, P.O. Box 48, East London, Cape Province.
1916. Carruthers, Somerville Craig, M.I.A.A., P.O. Box 266, Johannesburg.
1919. Cartwright, John Dean, M.P.C., c/o Cartwright's, Ltd., Adderley Street, Capetown.
1922. Carvalho, Commander A. de, Portuguese Navy, Lourenço Marques.
1919. Carveth, Frederick Charles, 26, Carrington Road, Kimberley.
1917. Cassell, Myer, B.Com., P.O. Box 5992, Johannesburg.

1916. CAWSTON, Frederic Gordon, B.A., M.D., M.R.C.S., L.R.C.P., 16, Britannia Buildings, Durban.
1903. CAZALET, Percy, M.I.M.M., White River, via Nel's Spruit, Transvaal.
1920. CHAPMAN, G. W., Stellenbosch, Cape Province.
1920. CHAPMAN, Mrs. G. W., Stellenbosch, Cape Province.
1918. CHAPMAN, Thomas Henry, P.O. Box 5291, Johannesburg.
1920. CHAPMAN, H. L., Huguenot College, Wellington, Cape Province.
1917. CHAPPELL, Sir Ernest, P.O. Box 1124, Johannesburg.
1913. CHARTERS, Robert Hearne, M.I.C.E., Professor of Civil Engineering, The University, Johannesburg.
1920. CHILTON, James, P.O. Box 14, Springs.
1921. CHUBB, E. C., Curator, The Museum, Durban.
1918. CLARK, George Muirhead, M.A., M.I.C.E., 15, Meischke's Buildings, Johannesburg.
1916. CLARK, Gowan Creswell Strange, C.M.G., c/o Railway Offices, Johannesburg.
1916. CLARK, Hugh, B.Sc., A.M.I.E.E., Technical College, Durban, Natal.
1916. CLAYDEN, Harold William, A.M.I.E.E., A.M.I.M.E., P.O. Box 1242, Johannesburg.
1917. CLEGHORNE, William Shaw Hamilton, B.Sc., A.M.I.Mech.E., Box 181, Potchefstroom, Transvaal.
1916. CLEPHAN, Miss Ethel Hunter, Girls' High School, Park Street, Pretoria.
1920. CLUVER, Professor E. H., B.A., M.B., Ch.B., The University, Johannesburg.
1920. COHEN, Miss N., B.A., Commercial High School, Johannesburg.
1922. COLBY, Mrs. Beatrice G., 51, Fortescue Road, Yeoville, Johannesburg.
1918. COLEMAN, Percy, M.A., 208, Union Buildings, Pretoria.
1916. COLLARD, J. Aldred, P.O. Box 4439, Johannesburg.
1908. COLLIE, J., 274, Eastwood Street, Arcadia, Pretoria.
1904. COLLINS, Ernest A. E., 66, Pritchard Street, P.O. Box 723, Johannesburg.
1920. COLLINS, S. N. C. P., P.O. Box 723, Johannesburg.
1906. COLLINS, M. R., Irrigation Department, P.O. Box 399, Pretoria.
1920. COLLY, Abe, P.O. Box 3583, Pretoria.
1917. COLQUHOUN, Ludovic, Dynamite Factory, Modderfontein, Transvaal.
1920. COMPTON, Professor R. H., M.A., Kirstenbosch, Newlands, Capetown.
1920. CONSTANTINE, Rev. A., B.A., The Manse, Paarl, Cape Province.
1904. COOPER, Fred W., Public Library, Port Elizabeth, Cape Province.
1918. COOPER, Messrs. William & Nephews, P.O. Box 4557, Johannesburg.
1919. CORDEAUX, Herbert John Charles, F.R.I.B.A., 45, Oxford Street, East London.
1920. CORNWALL, W. D., City Hall, East London.
1914. CORY, Sir George Edward, M.A., Professor of Chemistry and Metallurgy, Rhodes' University College, Grahamstown.
1921. COWAN, C. C., The Burlington Press, Von Weilligh Street, Johannesburg.
1922. COX, Dr. Alice, Maitland Street, Bloemfontein.
1916. COX, George Walter, F.R.Met.S., P.O. Box 399, Pretoria.
1902. COX, Walter Hubert, Royal Observatory, Capetown.
1909. CRAWFORD, David Chalmers, M.A., B.Sc.Agr., Elsenburg, Mulder's Vlei, Cape Province.
1902. CRAWFORD, Professor Lawrence, M.A., D.Sc., F.R.S.E., Department of Pure Mathematics, University of Capetown.
1918. CRAWFORD, William Heron, P.O. Box 15, Langlaagte, Transvaal.
1921. CRESWELL, F. H. P., D.S.O., M.L.A., Rand Club, Johannesburg.
1918. CRINSOZ DE COTTENS, Francois E., M.D., Ph.D., M.R.C.S., P.O. Box 5975, Johannesburg.

1918. Crinsoz de Cottens, Mrs. Marguerite, M.D., P.O. Box 5975, Johannesburg.
1916. Croghan, Dr., 28, High Road, Fordsburg, Johannesburg.
1916. Crookes, George Joseph, The Cedars, Renishaw, per Private Bag, Durban, Natal.
1919. Crosby, William, Editor, "Daily Dispatch," P.O. Box 141, East London.
1916. Cruden, Frank, Alicedale, Cape Province.
1903. Cullen, William, M.I.M.M., The Crossways, Avenue Elmers, Surbiton, Surrey, England.
1919. Cullinan, Sir Thomas, P.O. Box 286, Johannesburg.
1920. Curling, Major H. W., M.C., 2, Waterkant Street, Capetown.
1916. Currie, Richard, 112, Commissioner Street, Johannesburg.
1916. Curry, N. O., P.O. Box 2303, Johannesburg.
1920. Curson, H. H., M.R.C.V.S., Nagana Research Laboratory, P.O. Empangeni, Zululand.

1904. Dale, Hubert, P.O. Box 632, Johannesburg.
1903. Dalrymple, Sir W., P.O. Box 2927, Johannesburg.
1913. Damant, E. L., B.Sc., The University, Johannesburg.
1916. Danckwerts, Ernst, P.O. Box 486, Johannesburg.
1913. Daniel, John, Armley House, 30, Plein Street, Johannesburg.
1916. Davidson, D. M., P.O. Box 455, Germiston.
1917. Davidson, John, P.O. Box 1146, Johannesburg.
1920. Davie, T. B., B.A., 123, Juta Street, Wanderers' View, Johannesburg.
1920. Davie, Mrs. Vera, B.A., 123, Juta Street, Wanderers' View, Johannesburg.
1922. Davies, Evan, P.O. Box 4087, Johannesburg.
1918. Davies, David Ernest Lloyd, M.I.C.E., F.R.San.I., City Hall, Capetown.
1916. Davis, Carl Raymond, E.M., M.A.I.M.E., Consolidated Mines Selection Co., P.O. Box 1048, Johannesburg.
1903. Davis, Frederick H., B.Sc., M.I.E.E., P.O. Box 1934, Johannesburg.
1916. Deakin, James Alfred, Dunswart Iron and Steel Works, P.O. Box 290, Benoni, Transvaal.
1914. De Kock, Dr. Servaas Meyer, P.O. Box 321, Bloemfontein.
1915. De Kock, Professor G., M.R.C.V.S., Veterinary Research Laboratory, P.O. Box 593, Pretoria.
1917. De Korte, William Edmond, M.B., M.R.C.S., L.R.C.P., Lloyd's Buildings, Burg Street, Capetown.
1920. Delegation of the Chilean Nitrate of Soda Propaganda, Maitland Street, Bloemfontein.
1920. Delf, Miss E. Marion, D.Sc., Westfield College, London, N.W.
1915. Delfos, Cornelis Frederik, P.O. Box 24, Pretoria.
1921. Denhardt, Joseph Edward, 15-16, Hatfield House, Johannesburg.
1919. Denison, Professor R. B., D.Sc., Ph.D., Natal University College, Maritzburg.
1922. Department of Native Affairs, Pretoria.
1916. Des Clayes, Raymond, P.O. Box 155, Johannesburg.
1915. De Villiers, C. G. S., M.A., Ph.D., Stanford, Caledon, C.P.
1922. De Villiers, M., L.D.S., 36, Maitland Street, Bloemfontein.
1922. De Villiers, Mrs. M., 36, Maitland Street, Bloemfontein.
1916. De Villiers, Right Hon. Charles Percy, Baron, Rustenburg, Stellenbosch, Cape Province.
1921. Devitt, H. N., Magistrate's Court, Johannesburg.
1918. De Wet, Miss Frances Cole, M.A., Huguenot University College, Wellington, Cape Province.
1915. Dick, Colonel James, S. Thomas Road, Durban.
1916. Diethelm, Carl Robert, P.O. Box 3228, Johannesburg.
1920. Dix, F., B.Com., The University, Johannesburg.
1917. Dobson, Lieut.-Colonel Joseph Henry, D.S.O., M.Sc., M.Eng., M.I.Mech.E., M.I.E.E., A.M.I.C.E., P.O. Box 699, Johannesburg.

1921. DOCKRALL, B. W. B., P.O. Box 4755, Johannesburg.
1919. DODD, Benjamin Herbert, M.A., "Daily Dispatch" Office, East London.
1915. DOIDGE, Miss Ethel Mary, M.A., D.Sc., F.L.S., Division of Botany, P.O. Box 994, Pretoria.
1922. DORMEHL, P. L., Conservator of Forests, Bloemfontein.
1911. DORNAN, Rev. Samuel S., M.A., F.G.S., Phoenix Hotel, Beaconsfield, Cape Province.
1922. DOUGLAS, T., Afton Lodge, Parktown, Johannesburg.
1918. DOWLING, Walford Robert, M.I.M.M., P.O. Box 1167, Johannesburg.
1920. DOWLING, Mrs. F., P.O. Box 1167, Johannesburg.
1920. DOYLE, R. D., P.O. Box 937, Pretoria.
1908. DREGE, Isaac Louis, P.O. Box 148, Port Elizabeth.
1917. DRENNAN, Charles Maxwell, M.A., Professor of English, The University, Johannesburg.
1914. DREYER, P., Resident Magistrate's Office, Capetown.
1915. DREYER, Thomas F., B.A., Ph.D., Professor of Zoology, Grey University College, Bloemfontein.
1917. DREYFUS, Paul, P.O. Box 5836, Johannesburg.
1906. DRUCE, P. M., M.A., Parktown High School, Johannesburg.
1902. DRURY, Edward Guy Dru, M.D., B.S., D.P.H., Grahamstown, Cape Province.
1906. DUERDEN, James E., M.Sc., Ph.D., A.R.C.S., Professor of Zoology, Rhodes' University College, Grahamstown, C.P.
1915. DUMAT, Henry Aylmer, M.D., F.R.C.P.E., 49, Gardiner Street, Durban, Natal.
1910. DUNCAN, A., P.O. Box 1214, Johannesburg.
1904. DUNCAN, Hon. Patrick, C.M.G., M.L.A., Department of Interior, Union Buildings, Pretoria.
1909. DUNKERTON, Edward B., c/o Messrs. Lennon, Ltd., West Street, P.O. Box 266, Durban, Natal.
1922. DUNSTAN, Dr. J. T., Mental Hospital, Pretoria.
1917. DU PLESSIS, Rev. Professor Johannes, B.A., B.D., Theological Seminary, Stellenbosch, Cape Province.
1921. DU PLESSIS, I. P. J., School of Agriculture, Glen, O.F.S.
1917. DU TOIT, Alexander Logie, B.A., D.Sc., F.G.S., Irrigation Department, Union Buildings, Pretoria.
1913. DU TOIT, A. E., M.A., Professor of Mathematics, Transvaal University College, Pretoria.
1917. DU TOIT, Hendrik Lodewijk, Michville, via Honey Nest Kloof, Cape Province.
1920. DU TOIT, Professor P. J., B.A., Ph.D., Dr. Med. Vet., Veterinary Research Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1917. DU TOIT, Pieter Jacobus, B.A., Hilton College, Hilton Road, near Maritzburg.
1915. DU TOIT, Pieter Johannes, Secretary for Agriculture, Pretoria.
1911. DUTHIE, George, M.A., F.R.S.E., Concession Siding, Private Bag, Salisbury, Rhodesia.
1917. DUTHIE, Miss Augusta Vera, M.A., University of Stellenbosch.
1912. DWYER, Edward Burroughs, B.A., Forest Department, Kingwilliamstown, Cape Province.

1916. EADIE, Duncan McIntyre, 699, Currie Street, Durban, Natal.
1922. EARL, Miss J., B.Sc., Girls' High School, Barnato Park, Johannesburg.
1917. EAST LONDON Public Library, East London, Cape Province.
1904. EATON, William Arthur, 74, St. George's Street, Capetown.
1920. ECKBO N. B., Forest Department, Pretoria.
1920. EDMONDS, Miss M., Galloway House, Musgrave Road, Durban, Natal.
1911. EDWARDS, C. J., P.O. Box 242, Capetown.
1922. EDWARDS, Dr. Constance M., P.O. Box 288, Bloemfontein.

1920. Ellis, Leonard Erasmus, M.D., M.R.C.S., L.R.C.P., "Westlands," Junction Avenue, Parktown, Johannesburg.
1914. Elsdon-Dew, William, M.I.E.E., P.O. Box 4563, Johannesburg.
1920. Engels, K., L.D.S., Tudor Chambers, Pretoria.
1910. Engelenburg, Dr. F. V., Editor "De Volkstem," Pretoria.
1920. English, E. F., M.Sc., Department of Agriculture, Pretoria.
1918. Entomologist, Cape Province, Department of Agriculture, Parliament Street, Capetown.
1910. Erskine, J. K., F.C.S., P.O. Willowdene, near Johannesburg.
1922. Espinasse, James, B.A., 26, Kellner Street, Bloemfontein.
1918. Evans, Rev. Gregory, The Priory, Rosettenville, Johannesburg.
1918. Evans, Herbert, Cor. Von Brandis Square and Pritchard Street, Johannesburg.
1905. Evans, Iltyd Buller Pole, C.M.G., M.A., D.Sc., F.L.S., Chief of the Division of Botany and Plant Pathology, P.O. Box 994, Pretoria.
1905. Evans, Samuel, 153, Nugget Street, Johannesburg.
1916. Evans, S., Modder B.G.M. Co., Ltd., Benoni, Transvaal.
1921. Evans, H. D., P.O. Box 1231, Johannesburg.
1918. Evans, Rev. William Frederick, Verulam, Natal.
1914. Eveleigh, Rev. William, P.O. Box 708, Capetown.
1919. Everitt, Alfred Page, P.O. Box 20, Kingwilliamstown, Cape Province.
1904. Ewing, Sydney Edward Thacker, M.I.E.E., P.O. Box 2269, Johannesburg.
1906. Eyles, Frederick, F.L.S., M.L.C., c/o Department of Agriculture, Salisbury, Rhodesia.

1917. Fantham, Professor Harold B., M.A., D.Sc., F.Z.S., Department of Zoology, The University, Johannesburg.
1905. Farrar, Edward, Bleak Cottage, Park Street, Belgravia, Johannesburg.
1905. Feetham, Richard, M.L.A., Sauer's Buildings, Cor. Loveday and Market Streets, Johannesburg.
1918. Fernbank, Charles J., P.O. Box 3220, Johannesburg.
1921. Fergus, B. W. H., 33, Berg Street, Belgravia, Johannesburg.
1921. Fern, W. G., P.O. Box 900, Johannesburg.
1921. Fernhead, W., P.O. Box 3324, Johannesburg.
1922. Ferreira, J. F., Portuguese Consulate, Clonmel Chambers, Eloff Street, Johannesburg.
1903. Ffennell, R. W., c/o Central Mining and Investment Corporation, Ltd., 1, London Wall Buildings, London, E.C., England.
1921. Fielden, H., P.O. Box 7386, Johannesburg.
1915. Findlay, George Schriener, 151, Esselen Street, Pretoria.
1916. Findlay, Professor James, The University, Johannesburg.
1922. Fischer, P. U., B.A., LL.B., Southern Life Buildings, Bloemfontein.
1912. FitzSimons, F. W., F.Z.S., F.R.M.S., Director, Port Elizabeth Museum, Port Elizabeth, Cape Province.
1902. Flack, Archdeacon Francis Walter, M.A., The Rectory, Uitenhage, Cape Province.
1919. Fletcher, R. A., A.M.I.C.E., P.O. Box 71, Bulawayo.
1920. Fletcher, H.C., P.O. Box 224, Bulawayo.
1916. Fletcher, Richard Evelyn, King Edward VII. School, Johannesburg.
1902. Flint, Rev. William, D.D., Wolmunster Park, Rosebank, C.P.
1921. Floyd, G. E., Muir Cottage, Uitenhage, Cape Province. Capetown.
1918 Foote, H. J., M.B., Ch.B., L.D.S., 28, Estcourt Buildings, Johannesburg.
1907. Foote, J. A., F.G.S., F.E.I.S., Principal, Commercial High School, Johannesburg.
1921. Forbes, Miss H. M. L., Natal Herbarium, Durban, Natal.

1919. Ford, Rev. Canon E. B., M.A., Bayville, Oaklands Road, Grahamstown, Cape Province.
1917. Forest Department, Union Buildings, Pretoria.
1918. Forrest, Bryce Charles, A.I.M.M., P.O. Box 6973, Johannesburg.
1920. Forsyth, D. F., B.A., P.O. Box 18, Maritzburg.
1920. Forsyth, Miss M. N., P.O. Box 18, Maritzburg.
1914. Forsyth, Thomas M., M.A., D.Phil., Professor of Philosophy, Grey University College, Bloemfontein.
1921. Forsyth, G. A., P.O. Box 29, Johannesburg.
1922. Fox, R. H., Delagoa Bay Development Corporation, Lourenço Marques.
1905. Frames, P. Ross, C.M.G., P.O. Box 148, Johannesburg.
1906. Frankenstein, Miss Adelia, B.A., 9, Knight Street, Kimberley, Cape Province.
1916. Fraser, John, J.P., P.O. Box 149, Maritzburg.
1921. Fraser, Donald Alexander, P.O. Box 421, Johannesburg.
1916. Freeland, Hubert, P.O. Box 2863, Johannesburg.
1902. Fremantle, Henry Eardley Stephen, M.A., F.S.S., Upper Avenue, Stellenbosch, Cape Province.
1921. Frielinghaus, F. W., P.O. Box 26, Maraisburg, Transvaal.
1916. Frood, George Edward Bell, M.A., M.I.M.M., Mines Department, Windhoek, S.W. Protectorate.
1914. Frood, Dr. T. M., Rand Club, Johannesburg.
1902. Fuhr, Harry A., A.M.I.C.E., Public Works Department, Bloemfontein.
1918. Fulton, James Renwick, South African Railways Offices, Johannesburg

1907. Gairdner, Dr. J. Francis R., 754, Church Street, Arcadia, Pretoria.
1903. Galpin, Ernest Edward, F.L.S., Mosdene, Naboomspruit, Transvaal.
1922. Gardner, M. B., P.O. Box 1014, Johannesburg.
1915. Garlick, Miss Winifred Marguerite, Thornibrae, Green Point, Capetown.
1902. Gasson, William, F.C.S., Dutoitspan Road, Kimberley, C.P.
1904. Gellatly, John T. B., M.I.C.E., P.O. Box 37, Bethulie, O.F.S.
1918. George, Ernest, B.A., M.Sc., F.C.S., The University, Johannesburg.
1917. Gericke, Oney Mortimer, M.B., Ch.B., L.R.C.P., L.R.C.S., Forest Hill, Upper Buitekant Street, Capetown.
1920. Gibbs, T. J., B.Sc., Natal University College, Maritzburg.
1916. Gibson, James Young, 380, Longmarket Street, Maritzburg.
1902. Gilchrist, John Dow Fisher, M.A., D.Sc., Ph.D., F.L.S., C.M.Z.S., Professor of Zoology, University of Capetown.
1905. Gilchrist, W., M.S.A., P.O. Box 127, Capetown.
1910. Ginsberg, Franz., P.O. Box 3, Kingwilliamstown, Cape Province.
1910. Glyn, Charles, M.E., P.O. Box 193, Roodepoort, Transvaal.
1912. Goddard, Ernest James, B.A., D.Sc., Professor of Zoology, University of Stellenbosch, Cape Province.
1902. Godfrey, Rev. Robert, M.A., Blythswood Institution, Butterworth, Cape Province.
1920. Goetz, Rev. Father E., S.J., M.A., The Observatory, P.O. Box 172, Bulawayo, Rhodesia.
1922. Goldring, Clive, Jeppe High School, Johannesburg.
1922. Gomes, Madame D. V. B. de S. R., Auditoria, Lourenço Marques.
1916. Goodall, Frederick, P.O. Box 909, Durban, Natal.
1920. Gordon, Dr. Mary S., Blinman's Buildings, Johannesburg.
1904. Gorges, Sir Edward Howard Lacam, K.C.M.G., M.V.O., Pretoria Club, Pretoria.
1915. Gould, Robert Howe, P.O. Box 4941, Johannesburg.

1918. Grahamstown Public Library, P.O. Box 30, Grahamstown, Cape Province.
1921. Graham, C. E., P.O. Box 1463, Johannesburg.
1922. Grainger, Joachim J., P.O. Box 118, Lourenço Marques.
1908. Grant, Charles, M.A., P.O. Box 392, Pretoria.
1919. Grant, George, General Manager's Office, African Banking Corporation, Capetown.
1914. Grant, William Frank, B.Sc., P.O. Box 1013, Johannesburg.
1907. Gray, Charles Joseph, P.O. Box 1072, Johannesburg.
1907. Gray, James, F.I.C., P.O. Box 5254, Johannesburg.
1915. Green, Professor Henry Hamilton, D.Sc., F.C.S., Veterinary Laboratory, Onderstepoort, P.O. Box 593, Pretoria.
1921. Green, F. V., P.O. Box 7017, Johannesburg.
1916. Greenacre, Walter, "Waveney," Musgrave Road, Durban, Natal.
1921. Gregor, W. T., 59, Luipaard Street, Krugersdorp.
1920. Grice, L. C., Municipal Buildings, Durban.
1919. Griffin, Rev. A. Eben, The Parsonage, Kingwilliamstown.
1916. Griffin, Joseph D., P.O. Box 2155, Johannesburg.
1922. Griffin, Thomas Fidler, P.O. Box 1465, Johannesburg.
1921. Grills, E. R., P.O. Box 1020, Johannesburg.
1906. Grimmer, Irvine Rowell, Assistant General Manager, De Beers Consolidated Mines, Ltd., Kimberley, Cape Province.
1916. Grindley-Ferris, Vyvyan, B.Sc., Consolidated Goldfields of South Africa, Ltd., Johannesburg.
1917. Grobbelaar, Coert Smit, M.A., Heemstede, Van Riebeek Street, Stellenbosch, Cape Province.
1912. Gubbins, John Gaspard, B.A., Ottoshoop, Transvaal.
1913. Gundry, Philip G., B.Sc., Ph.D., A.R.C.S., Professor of Physics, Transvaal University College, Pretoria.
1915. Gunn, David P., P.O. Box 597, Port Elizabeth, Cape Province.
1905. Gutsche, Phillip, M.D., Villa Torrita, Kingwilliamstown, Cape Province.
1903. Gyde, Charles J., A.M.I.C.E., Public Works Department, Union Buildings, Pretoria.

1904. Haagner, Alwyn K., Hon. D.Sc., F.Z.S., Zoological Gardens, P.O. Box 754, Pretoria.
1916. Haig, W., c/o Messrs. Fraser & Chalmers, Ltd., Corner House, Johannesburg.
1907. Hall,, Carl, A.M.I.C.E., F.G.S., 28, Club Arcade, Durban, Natal.
1910. Halm, Jacob K. E., Ph.D., F.R.S.E., Royal Observatory, Cape Province.
1921. Halm, E. A., Technical College, Durban, Natal.
1922. Hamlin, Dr. E. J., Stellenbosch, Cape Province.
1907. Hammar, August, 441, Burger Street, Maritzburg, Natal.
1902. Hancock, H., A.M.I.C.E., 5, Castle Street, Liskeard, Cornwall, England.
1903. Hancock, Strangman, M.Am.I.M.E., Kennel Holt, Cranbrook, Kent, England.
1920. Harries, C. L. R., P.O. Haman's Kraal, District Pretoria.
1904. Harries, W. M., P.O. Box 2189, Johannesburg.
1905. Harris, Lionel, M.E., B.Sc., 113, Sivewright Avenue, Doornfontein, P.O. Box 1311, Johannesburg.
1921. Harris, R. H. T. P., Farm 273, Empangeni, Zululand.
1918. Harrison, Thomas Hendry, P.O. Box 74, Kingwilliamstown, Cape Province.
1916. Hastings, Miss Isabel, Oaklands School, Harrismith, O.F.S.
1917. Hawkins, John Charles, A.M.I.C.E., A.M.I.Mech.E., P.O. Box 54, Vereeniging, Transvaal.
1916. Hay, William, J.P., P.O. Box 521, Capetown.
1921. Hay, R. G., P.O. Box 6814, Johannesburg.
1922. Hayhoe, D. G., P.O. Box 1540, Johannesburg.
1920. Hayter, C. S., Private Post Bag, Maritzburg, Natal.

1916. Heather, Hendry James Shedlock, B.A., M.I.C.E., M.I.E.E., F.Am.I.E.E., Professor of Electrotechnics, The University, Johannesburg.
1916. Healey, John Edward, P.O. Box 2, Maraisburg, Transvaal.
1921. Heanan, Miss M., Government School, Roberts Heights, Pretoria.
1920. Hebditch, Miss G. E., Huguenot College, Wellington, Cape Province.
1914. Henderson, Miss Janetta, c/o Dr. J. B. H. Ruthven, P.O. Box 6253, Johannesburg.
1902. Henkel, John Spurgeon, Department of Agriculture, Salisbury, Rhodesia.
1918. Hepburn, Rev. Ivan Dawson, B.A., c/o Sudan United Mission, Muri Province, Northern Nigeria.
1904. Herdman, G. W., M.A., M.I.C.E., Assistant Director of Irrigation, Union Buildings, Pretoria.
1919. Hessenauer, Herman Charles, L.D.S., 108 Oxford Street, East London.
1911. Hewetson, W. M., M.B., D.P.H., J.P., Sinoia, Southern Rhodesia.
1909. Hewitt, John, B.A., Director of the Albany Museum, Grahamstown, Cape Province.
1915. Hewitt, Strafford Smith, P.O. Box 192, Bloemfontein.
1909. Heymans, Dr. G., M.A., 702, Church Street, Arcadia, Pretoria.
1917. Hilhorst, Henri, P.O. Box 484, Pretoria.
1918. Hirschhorn, Friedrich, P.O. Box 40, Kimberley.
1916. Hodges, Miss Ruth Mary, B.Sc., Wykeham School, Maritzburg.
1917. Hofmeyr, Jan Hendrik, M.A., Principal, University of the Witwatersrand, Johannesburg.
1919. Hofmeyr, Rev. Hendrik Moleps, Private Bag, Pietersburg, Transvaal.
1921. Hoffman, G. F., Muir College, Bloemfontein.
1921. Hoffman, W. S., M.A., Edwaleni High School, Izingolweni, Natal.
1921. Honey, C. H., P.O. Box 1011, Johannesburg.
1919. Holloway, Professor John Edward, B.A., D.Sc., Transvaal University College, Pretoria.
1902. Honnold, W. L., Hyde Park Hotel, 66, Knightsbridge, London, S.W., England
1902. Horne, William James, A.M.I.C.E., A.M.I.E.E., c/o Trades School, Smit Street, Johannesburg.
1918. Hortor, William Edward, "Trevadlock," Campbell Road, Parktown, West, Johannesburg.
1922. Horwich, Dr. D., P.O. Box 503, Johannesburg.
1921. Hosken, H., P.O. Box 667, Johannesburg.
1921. Hoskings, E. O., 115, Hunter Street, Bellvue, Johannesburg.
1902. Hough, Sydney Samuel, M.A., F.R.S., Astronomer Royal, Royal Observatory, near Capetown.
1920. Howman, E. G., Sinoia, Southern Rhodesia.
1905. Humphrey, William Alvara, B.A., Ph.D., F.G.S., Vryheid, Natal.
1912. Hunt, Donald Rolfe, Sub-Native Commissioner, Sekukuniland, Lydenburg, Transvaal.
1921. Hutcheson, John, P.O. Box 4854, Johannesburg.
1916. Hutton, C. E., P.O. Box 164, Germiston, Transvaal.
1918. Hutton, Herbert Beavor, P.O. Box 44, Kingwilliamstown, Cape Province.
1920. Hyman, L. H., 411, Smith Street, Durban, Natal.

1916. Imroth, G., Johannesburg Consolidated Investment Buildings, Johannesburg.
1913. Ingham, William, M.I.C.E., M.I.M.E., Chief Engineer's Office, Rand Water Board, P.O. Box 1703, Johannesburg.
1922. Ingham, F. E., P.O. Box 1703, Johannesburg.

1921. Ingle, A. E., Palmhurst, Silver Oak Avenue, Overpoort, Durban, Natal.
1907. Innes, Hon. Sir James Rose-, K.C.M.G., B.A., L.L.B., Chief Justice of the Union of South Africa, Capetown.
1902. Innes, Robert Thorburn Ayton, F.R.A.S., F.R.S.E., Union Observatory, Johannesburg.
1908. Institute of Government Land Surveyors, Cape of Good Hope Savings Bank Buildings, Capetown.
1921. Iowa State College Library, Ames, Iowa, U.S.A.

1915. Jackson, Harry Percival, M.Sc., Jeppe High School, Johannesburg.
1922. Jackson, W. B., P.O. Box 4570, Johannesburg.
1904. Jagger, Hon. J. W., F.S.S., M.L.A., P.O. Box 258, Capetown.
1920. Jamieson, Mrs. E., P.O. Box 357, Johannesburg
1920. Jamieson, E. C., Brown's Buildings, Loveday Street, Johannesburg.
1915. Janse, Antonius Johannes Theodorus, F.E.S., Lecturer in Biology, Normal College, Pretoria, First Street, Gezina, Pretoria.
1919. Jardine, Major W., "Craigdhu," Tamboer's Kloof, Capetown.
1911. Jarvis, E. M., F.R.C.V.S., Pelf's Estate, P.O. Box 14, Umtali, Rhodesia.
1910. Jeffrey, John, P.O. Box 40, Capetown.
1922. Jeffreys, Mrs. L., P.O. Box 1183, Johannesburg.
1921. Jenkins, B., P.O. Box 399, Johannesburg.
1920. Jennings, A. C., A.M.I.C.E., P.O. Box 387, Salisbury, Rhodesia.
1913. Jensen, Alex. Emil, B.Sc. Eng., 73, Kitchener Avenue, Bezuidenhout Valley, Johannesburg.
1916. Jensen, Ragnvald, C.E., P.O. Box 1361, Johannesburg.
1916. Joel, Solomon Barnato, P.O. Box 433, Johannesburg.
1912. Johnson, Miss Alta, Ph.B., New Street, Wellington, Cape Prov.
1912. Johnson, George Lindsay, M.A., M.D., Britannia Buildings, West Street, Durban, Natal.
1909. Johnson, W., L.R.C.P., L.R.C.S., 3, Link Road, Bloemfontein.
1914. Johnson, W.S., M.A., Professor of English, Grey University College, Bloemfontein.
1917. Jones, Daniel Johnes, 83a, Ferreira Street, Turffontein.
1920. Jones, J. D. R., Witwatersrand Council of Education, P.O. Box 854, Johannesburg.
1920. Jones, Mrs. J. D. R., Jeppe High School for Girls, Johannesburg.
1920. Jones, G. C., P.O. Box 987, Johannesburg.
1916. Jones, J. E., P.O. Box 2354, Johannesburg.
1917. Jones, Levi David, B.Sc., Commercial High School, Johannesburg.
1921. Jones, H. E., B.A., Technical College, Durban, Natal.
1920. Jordan, Miss G. W., B.A., Junior Student Centre, Doornfontein, Johannesburg.
1911. Joubert, M. J., B.Sc.Agr., Department of Agriculture, Bloemfontein.
1920. Jourd, W. T., P.O. Box 226, Boksburg, Transvaal.
1920. Judson, D., M.I.E.E., Bulawayo, Rhodesia.
1905. Junod, Rev. Henri A., c/o Mission Suisse Romande, Chemin des Cedres, Lausanne, Switzerland.
1922. Junod, H. P., B.A., B.D., P.O. Box 21, Lourenço Marques.
1920. Jurgens, Miss K., c/o Rev. Stander, Barberton, Transvaal.
1903. Juritz, Charles Frederick, M.A., D.Sc., F.I.C., Chief of Division of Chemistry, Department of Agriculture, Capetown.

1907. Kanthack, Francis Edgar, C.M.G., M.I.C.E., M.I.M.E., 5, Winchester House, Johannesburg.
1918. Karnovsky, Herman Louis, P.O. Box 5933, Johannesburg.

1921. KAYSER, C. F., Park Drive, Port Elizabeth, Cape Province.
1912. KEHOE, Professor D., M.R.C.V.S., Royal Veterinary College of Ireland, Ballsbridge, Dublin, Ireland.
1920. KEIGWIN, H. S., M.A., Salisbury, Rhodesia.
1921. KENNEDY, W. P., B.Sc., Maritzburg College, Maritzburg, Natal.
1903. KENT, Professor Thomas Parkes, M.A., University of Capetown.
1919. KERR, Alexander, M.A., Principal, South African Native College, Fort Hare, Alice, Cape Province.
1921. KEY, A. Cooper, P.O. Box 3621, Johannesburg.
1920. KILROE, Professor Miss F. C., B.Sc., Huguenot College, Wellington, Cape Province.
1905. KING, Austin, Director of Mines, Macequese, Portuguese East Africa.
1915. KING, Francis Edward, P.O. Box 802, Pretoria.
191-. KINGON, Rev. John Robert Lewis, M.A., D.Sc., F.R.S.E., F.L.S., The Manse, Lower Main Road, Observatory, Cape Province.
1919. KINGWILLIAMSTOWN Public Library, Kingwilliamstown, Cape Province.
1906. KINGWILLIAMSTOWN Museum, Kingwilliamstown, Cape Province.
1921. KIRBY, Professor P. R., M.A., A.R.C.M., The University, Johannesburg.
1913. KIRKLAND, John Wilkinson, M.Am.I.E.E., P.O. Box 1905, Johannesburg.
1909. KIRKMAN, John, J.P., M.P.C., 331, Musgrave Road, Durban.
1916. KLEUDGEN, Caesar, P.O. Box 1164, Johannesburg.
1916. KLOOT, Alfred Aaron, B.Sc., A.I.C., West Street, Durban.
1902. KNAPP, Arthur D., Chikondi Estate, Neno Post Office, British Central Africa.
1920. KOK, Mathy Johannes, Commercial High School, Krugersdorp.
1902. KOLBE, Rev. Frederick Charles, B.A., D.D., St. Mary's Presbytery, Capetown.
1921. KOPE, G. S., Cor. Sixth and Third Avenues, Rosebank, Johannesburg.
1903. KOTZE, Sir Robert W. N., Kt., B.A., P.O. Box 1132, Johannesburg.
1918. KRAUSE, Frederick Edward Trangott, B.A., LL.D., P.O. Box 2345, Johannesburg.
1916. KRAUSE, Herbert Louis, A.S.M., P.O. Box 193, Germiston, Transvaal.
1922. KRIGE, A. V., M.Sc., Victoria Street, Stellenbosch, Cape Prov.
1920. KRIGE, E. W., Ceres, Cape Province.
1920. KRIGE, Mrs. E. W., Ceres, Cape Province.
1917. KRIGE, Professor Jacob Daniel Alphonse, Ph.D., The University, Johannesburg.
1922. KRIEL, Mrs. L. M., The Parsonage, Utrecht, Natal.
1921. KROONSTAD Public Library, Kroonstad, O.F.S.
1920. KUPFERBURGER, W., M.Sc., The University, Johannesburg.

1922. LADLER, Miss E. N., B.Sc., Huguenot College, Wellington, C.P.
1917. LAIDLER, Percy Ward, L.D.S., L.R.C.P., L.R.C.S., F.S.A., "Seaford," Main Road, Sea Point, Capetown.
1919. LAMBE, John Mordy, City Electrical Engineer, Town Hall, East London, Cape Province.
1916. LAMONT, William John, Grootfontein School of Agriculture, Middelburg, Cape Province.
1918. LANDAU, Arthur, P.O. Box 3378, Johannesburg.
1913. LANDAU, Nathan, Survey Office, Oogies Colliery, P.O. Oogies, Transvaal.
1914. LANGE, Hon. Justice Sir Johannes H., Kt., LL.B., Judge's Chambers, Kimberley, Cape Province.
1903. LASCHINGER, E. J., B.A.Sc., M.E., M.I.M.M., P.O. Box 4563, Johannesburg.
1920. LAWRIE, John E.C., P.O. Box 3927, Johannesburg.

1921. **Lazar**, O., c/o H. Comerimer, 29, Potsdamer Strasse, Berlin. Germany.
1921. **Le May**, H., M.A., B.Sc., The University, Johannesburg.
1903. **Legat**, C. E., B.Sc., Chief Conservator of Forests, Pretoria.
1904. **Leeds**, R. Q., P.O. Box 928, Johannesburg.
1907. **Lehfeldt**, Robert A., B.A., D.Sc., Professor of Economics, The University, Johannesburg.
1908. **Leighton**, James, F.R.H.S., P.O. Box 86, Kingwilliamstown.
1902. **Lenz**, O., P.O. Box 92, Johannesburg.
1919. **Leonard**, Charles Henry Branold, Mount Nelson Hotel, Capetown.
1921. **Leon**, Claude, P.O. Box 1988, Johannesburg.
1922. **Leon**, Aubrey Lester, P.O. Box 1998, Johannesburg.
1921. **Leon**, P. A., P.O. Box 1101, Johannesburg.
1916. **Leslie**, Robert, M.A., F.S.S., Jagger Professor of Economics, University of Capetown.
1916. **Leslie**, T. N., F.G.S., F.R.Met.S., P.O. Box 23, Vereeniging. Transvaal.
1921. **Lestarde**, G. P., Harvard University, Harvard, U.S.A.
1908. **Leviseur**, M., Bloemfontein.
1918. **Levy**, Joseph Langley, P.O. Box 1138, Johannesburg.
1903. **Lewis**, Leon, Zeven Rivieren, Ban Houek, Stellenbosch.
1920. **Liebson**, J., P.O. Box 5996, Johannesburg.
1918. **Lister**, Sir Frederick Spencer, M.R.C.S., L.R.C.P., "Cranbrook," Jan Smuts Avenue, Westcliff, Johannesburg.
1922. **Livie-Noble**, F. S., St. Paul's Hostel, Grahamstown, C.P.
1916. **Loeser**, Dr. F. H., Crown Mines, Ltd., Johannesburg.
1916. **Logan**, James Patterson, F.S.A.A., Town Hall, Bloemfontein.
1903. **Logeman**, William H., M.A., Professor of Physics, Grey University College, Bloemfontein.
1922. **Long**, A. G., 21, Berea Road, Bertrams, Johannesburg.
1916. **Loram**, Charles Templeman, M.A., LL.B., Ph.D., Education Department, Maritzburg.
1903. **Lorentz**, Henri, P.O. Box 55, Johannesburg.
1902. **Lounsbury**, Charles Pugsley, B.Sc., F.E.S., Chief of the Division of Entomology, P.O. Box 513, Pretoria.
1920. **Louw**, J. P. de V., Zand Drift, Stellenbosch, Cape Province.
1920. **Louw**, Mrs. J. P., Zand Drift, Stellenbosch, Cape Province.
1920. **Lowenstein**, Dr. Lilian, M.R.C.S., L.R.C.P., 24, Patlansky's Buildings, Johannesburg.
1922. **Lowe**, George Osborn, P.O. Box 2483, Johannesburg.
1922. **Loze**, Rev. P., P.O. Box 21, Lourenço Marques.
1902. **Lunt**, Joseph, D.Sc., F.I.C., Royal Observatory, Capetown
1921. **Lucas**, F. A. W., 42, Sauer's Buildings, Johannesburg.
1922. **Luckie**, W. B., P.O. Box 126, Lourenço Marques.
1902. **Lynch**, Major F. S., J.P., Kimberley Waterworks Co., Ltd., P.O. Box 650, Kimberley, Cape Province.
1917. **Lyons**, Joseph, A.R.C.S., c/o Joseph Baynes, Ltd., Nel's Rust. Natal.

1920. **Mace**, Miss E., Girls' Collegiate School, Maritzburg.
1908. **Macfadyen**, William Allison, M.A., LL.D., Professor of Philosophy, Transvaal University College, Pretoria.
1921. **Macfie**, T. G., Barsdorf Buildings, Johannesburg.
1921. **Macintyre**, Major W., P.O. Box 7095, Johannesburg.
1917. **MacColl**, Rev. John A., M.A., c/o J. J. Simpson, P.O. Box 64, Johannesburg.
1918. **MacIntyre**, Alexander Stewart, Government Industrial School. Maseru, Basutoland.
1921. **MacKay**, D. W., P.O. Box 251, Johannesburg.
1922. **MacKenzie**, J. N., P.O. Box 545, Johannesburg.
1914. **Macmillan**, Professor W. M., M.A., The University, Johannesburg.
1920. **MacKenzie**, J., 107, S.A. Railways, Johannesburg.

1905. McArthur, Duncan Campbell, M.R.C.S., L.R.C.P., Muizenburg, Cape Province.
1917. McCrae, John, Ph.D., F.I.C., P.O. Box 1080, Johannesburg.
1920. McCormack, M., Rand Water Board, Johannesburg.
1918. McCowat, Dr. W. M., P.O. Box 318, Johannesburg.
1919. McCurdy, Joseph Campbell, P.O. Box 6, Kingwilliamstown, Cape Province.
1908. McCrae, H. J., P.O. Box 817, Johannesburg.
1916. McDonald, David Paterson, M.A., B.Sc., P.O. Box 1170, Johannesburg.
1909. McDonald, G., M.A., Normal Training College, Bloemfontein.
1902. McEwen, T. S., A.M.I.C.E., "The Links," Rondebosch, Cape Province.
1922. McEwen, T. W. H., P.O. Box 2827, Johannesburg.
1909. McFeggans, Alexander, P.O. Box 26, Umtata, Cape Province.
1920. McGregor, A. M., B.A., F.G.S., P.O. Box 366, Salisbury, Rhodesia.
1914. McGregor, Rev. Andrew Murray, M.A., B.D., Blommestein, Three Anchor Bay, Capetown.
1921. McIntosh, P. R., "Tyrie," Ninth Avenue, Mayfair, Johannesburg.
1916. McKay, Mrs. Helen Millar, Malvern West Government School, Johannesburg.
1904. McKenzie, Archibald, M.D., C.M., M.R.C.S., Glen Lyon, Musgrave Road, Durban, Natal.
1920. McKenzie, Dr. A. J., Gatooma, Rhodesia.
1917. McLaren, James, M.A., Carshead Farm, Crieff, Scotland.
1918. McLaren, Mrs. Florence V., 36, St. George's Street, Yeoville, Johannesburg.
1915. McLoughlin, Captain Alfred George, Assistant Resident Magistrate, Qumbu, Cape Province.
1919. McMillan, David, J.P., 47, St. Peter's Road, P.O. Box 169, East London, Cape Province.
1919. Main, John, P.O. Box 38, Capetown.
1921. Maingard, Professor L. F., D.Lit., The University, Johannesburg.
1919. Maisels, Israel, M.B., Ch.B., L.M., 74, Kruis Street, Johannesburg.
1920. Malan, Hon. Francois Stephanus, B.A., LL.D., M.L.A., P.O. Box 450, Pretoria.
1912. Malherbe, D. F. du Toit, M.A., Ph.D., Professor of Chemistry, Transvaal University College, Pretoria.
1904. Malherbe, H. L., P.O. Box 208, Pretoria.
1917. Malleson, Percy Rodburd, F.R.H.S., Ida's Valley, Stellenbosch, Cape Province.
1902. Mally, Charles William, M.Sc., F.E.S., F.L.S., Division of Entomology, Department of Agriculture, Capetown.
1921. Manduell, M. D., M.A., Jeppe High School, Johannesburg.
1922. Manners, Philip Henry, 51, Fortescue Road, Yeoville, Johannesburg.
1915. Manning, Charles Nicholson, P.O. Box 98, Pietersburg, Transvaal.
1919. Marchand, Mrs. Annabel W., Parsonage, Vredenburg, Cape Province.
1915. Marchand, Bernard de Coligny, B.A., D.Sc., Chemical Laboratory, Department of Agriculture, Pretoria.
1902. Marloth, Professor Rudolph, M.A., Ph.D., P.O. Box 359, Capetown.
1919. Marsh, A. C., New Law Courts, Johannesburg.
1916. Marshall, William Benjamin, P.O. Box 159, Maritzburg.
1920. Mause, W., P.O. Box 2762, Johannesburg.
1911. Maufe, Herbert Brentwood, B.A., F.G.S., P.O. Box 366, Salisbury, Rhodesia.

1920. Mavrogordato, A., M.A., M.R.C.S., South African Institute for Medical Research, P.O. Box 1038, Johannesburg.
1902. Melle, G. J. McCarthy, M.B., c/o Zaaiplaats Tin Mining Co., Ltd., Potgietersrust, Transvaal.
1920. Mellish, A. D., Victoria Club, Maritzburg.
1903. Mellor, Edward T., D.Sc., M.I.M.M., F.G.S., P.O. Box 1056, Johannesburg.
1902. Menmuir, R. W., A.M.I.C.E., National Mutual Buildings, Church Square, Capetown.
1920. Mennell, F. P., F.G.S., M.I.M.M., P.O. Box 490, Bulawayo.
1917. Mercier, David Pyne, B.A., Kearsney College, Kearsney, Natal.
1921. Merkin, J. C., 33, Aegis Buildings, Johannesburg.
1920. Mettam, Professor R. W. M., M.R.C.V.S., The University, Johannesburg.
1914. Mesham, Professor Paul, M.A., M.Sc., Natal University College, Maritzburg.
1902. Metcalf, Sir Charles, Bart., M.I.C.E., 21, Pall Mall, London, S.W., England.
1916. Meyer, Edward C. J., B.Sc., P.O. Box 57, East Rand, Transvaal.
1917. Miller, Thomas Maskew, M.B.E., P.O. Box 396, Capetown.
1922. Millin, Advocate P., 47, Sauer's Buildings, Johannesburg.
1917. Mills, Frederick William, M.I.E.E., Headquarters, South African Railways, Johannesburg.
1920. Miolee, W. F., P.O. Box 362, Bulawayo, Rhodesia.
1915. Mitchell, David Thomas, M.R.C.V.S., Veterinary Research Laboratory, Armoedsvlakte, Vryburg, Cape Province.
1916. Mitchell, Hugh, P.O. Box 98, Langlaagte, Transvaal.
1916. Mitchell, John Jeppes, Central Government School, Johannesburg.
1915. Mogg, Albert Oliver Dean, B.A., Veterinary Research Laboratory, P.O. Box 593, Pretoria.
1917. Moir, James, M.A., D.Sc., F.I.C., P.O. Box 1080, Johannesburg.
1912. Moll, Dr. A. M., P.O. Box 4708, Johannesburg.
1922. Moll, Dr. Jan Marius, 5, Anstey's Buildings, Johannesburg.
1918. Montgomery, Robert Eustace, M.R.C.V.S., Director of Veterinary Research, Nairobi, British East Africa.
1922. Montgomery, Thomas, P.O. Box 552, Bloemfontein.
1922. Moon, R. H., P.O. Box 6341, Johannesburg.
1916. Moore, Miss Mary Elizabeth Constance, Wykeham School, Maritzburg.
1919. Moore, Willie Paton, "Somerset," Gorleston Road, Sea Point, Capetown.
1920. Moore, G. F., P.O. Box 453, Johannesburg.
1903. Morice, Advocate George T., B.A., K.C., 28, Sauer's Buildings, Johannesburg.
1921. Morice, Andrew, 1, Alliance Buildings, Fox Street, Johannesburg.
1920. Morris, J. F., Chief Lab. Officer, Vereeniging, Transvaal.
1919. Morris, Reginald James, Borough Engineer's Office, Kingwilliamstown, Cape Province.
1919. Morris, Frank, B.Sc., University College, Maritzburg.
1916. Morrison, John Todd, M.A., B.Sc., F.R.S.E., A.M.I.E.E. Professor of Applied Mathematics, University of Stellenbosch, Cape Province.
1916. Morton, David Thomas, West Rand Consolidated Mines, Transvaal
1920. Morton, J. S., High School, Turffontein, Johannesburg.
1917. Moss, Professor Charles Edward, M.A., D.Sc., F.L.S., F.R.G.S., Department of Botany, The University, Johannesburg.
1920. Moss, Mrs. C. E., M.A., The University, Johannesburg.
1918. Moss-Morrison, Bernard, P.O. Box 4800, Johannesburg.
1920. Mossop, George Edward, Vrede, O.F.S.

1921. Mulder, Willem, M.D., P.O. Box 395, Durban.
1902. Muir, Sir Thomas, Kt., C.M.G., M.A., LL.D., F.R.S., F.R.S.E., Elmsote, Sandown Road, Rondebosch, Capetown.
1915. Munro, H. K., B.Sc., Government Entomologist, East London.
1916. Munro, John, P.O. Box 433, Johannesburg.
1917. Murray, Charles, M.A., Herold Street, Stellenbosch, Cape Prov.
1904. Murray, George Alfred Everett, M.D., F.R.C.S., L.R.C.P., P.O. Box 105, Johannesburg.
1918. Murray, John, M.I.Mech.E., c/o The African Agricultural Estates, Ltd., Movene Estates, Bohane, Lourenço Marques.
1922. Murray, W. F., 15, Milner Road, Bloemfontein.
1919. Myers, Benjamin, 68, Oxford Street, East London, Cape Prov.

1916. Narbeth, Benjamin Mason, B.Sc., F.C.S., Principal, Technical College, Durban, Natal.
1910. Nauta, Professor Renicus Dowe, University of Capetown.
1917. Nay, Arthur Mac, M.I.Mech.E., P.O. Box 951, Durban, Natal.
1916. Neame, Hugh Austin, P.O. Box 3921, Johannesburg.
1905. Neilson, A. M., Manager, Safco Fertilizers Co., Umbilo, Natal.
1922. Nel, Professor G. C., B.A., Ph.D., University of Stellenbosch, Cape Province.
1918. Nelson, George William, P.O. Box 841, Johannesburg.
1919. Nettleton, George Augustus, Keiskama Hoek, Kingwilliamstown, Cape Province.
1915. New York Public Library, Forty-second Street and Fifth Avenue, New York City, U.S.A.
1920. New Transvaal Chemical Co., Delmore, Transvaal.
1917. Newberry, H., P.O. Box 225, Benoni, Transvaal.
1920. Newbery, Professor E., D.Sc., The University, Capetown.
1922. Newell, Dr. Annie G., Huguenot College, Wellington, C.P.
1914. Newhall, Percy Melrose, B.Sc., P.O. Box 1169, Johannesburg.
1916. Newhouse, Hans, P.O. Box 1156, Johannesburg.
1920. Newman, R. W., Lake Mentz, via Wolvefontein.
1921. Nichols, L. H., P.O. Box 3662, Johannesburg.
1917. Nicholson, Alfred, Schoongezicht, Stellenbosch, Cape Province.
1902. Nicholson, George Taylor, M.I.C.E., Resident Engineer, Docks, Capetown.
1904. Nixon, Edward John, M.R.C.S., L.R.C.P., P.O. Box 57, Heidelberg, Transvaal.
1902. Nobbs, Eric Arthur, Ph.D., B.Sc., F.R.H.S., Director of Agriculture, Salisbury, Rhodesia.
1922. Norman, H. E., 54, Magistrate's Court, Johannesburg.
1915. Norton, Rev. Professor William Alfred, M.A., B.Litt., Burnham Road, Seapoint, Capetown.
1921. Norris, G. Chad, 4, South Street, Grahamstown, Cape Prov.

1920. Oakshott, H. C. G., P.O. Box 52, Boksburg, Transvaal.
1917. Odgers, W., Rand Club, Johannesburg.
1922. Oettle, Geo. S., S.A. Railways and Harbours, Johannesburg.
1907. Ogg, Alexander, M.A., B.Sc., Ph.D., Professor of Physics, The University, Capetown.
1922. Ogilvie, P.A., 6, Harley Street, Yeoville, Johannesburg.
1921. Orenstein, Mrs. K., P.O. Box 1056, Johannesburg.
1915. Orenstein, Alexander Jeremiah, C.M.G., M.D., M.R.C.S., L.R.C.P., P.O. Box 1056, Johannesburg.
1906. Orpen, Joseph Millerd, Mon Asile, 43, St. Mark's Road, East London.
1902. Orr, John, O.B.E., B.Sc., M.I.C.E., M.I.Mech.E., Professor of Mechanical Engineering, The University, Johannesburg.
1920. Otten, F. J., B.A., Public School, Belfast, Transvaal.
1916. Otto, Cyril Saxon Douglas, Otto's Bluff, Natal.
1919. Owen, William Alfred, P.O. Box 111, Kingwilliamstown, Cape Province.
1919. Page, R. A., M.A., Rhodes' University College, Grahamstown,

1920. Paine, Professor H. H., M.A., B.Sc., The University, Johannesburg.
1905. Paisley, William, M.B., B.Ch., P.O. Box 127, Queenstown, Cape Province.
1920. Palmer, J. C., Diocesan Training College, Pietersburg, Transvaal.
1920. Palmer, Mrs. Mabel, M.A., Technical College, Durban, Natal.
1908. Palmer, W. Jarvis, B.Sc.Ag., P.O. Box 4557, Johannesburg.
1905. Papenfus, H. B., K.C., M.L.A., P.O. Box 5155, Johannesburg.
1920. Parkes, Edward B. H., B.A., P.O. Box 593, Pretoria.
1914. Parry, John, c/o De Beers Mines, Ltd., 17, Hull Street, Kimberley.
1921. Parish, E., B.Sc., Department of Agriculture, Pretoria.
1920. Paterson, Professor A. C., M.A., Transvaal University College, Pretoria.
1920. Paterson, A., c/o Wells & Co., Bathurst Street, Grahamstown, Cape Province.
1902. Pattrick, C. Beaufoy, A.M.I.C.E., Froneithysi, Aberdovey, North Wales.
1903. Payne, Albert E., A.R.S.M., P.O. Box 15, Langlaagte, Transvaal.
1919. Peacock, Henry Christopher, East London, Cape Province.
1916. Pearce, William, Lower Illovo, Natal.
1921. Pearse, Professor G. E., A.R.I.B.A., The University, Johannesburg.
1916. Pellissier, Rev. George Murray, B.A., B.D., Dundee, Natal.
1913. Peres, Dr. Manoel A., Jr., Director, Observatorio Campos Rodrigues, P.O. Box 256, Lourenço Marques.
1907. Peringuey, Louis Albert, D.Sc., F.E.S., F.Z.S., Director, South African Museum, Capetown.
1910. Perold, Abraham Izak, B.A., Ph.D., Professor of Viticulture and Oenology, University of Stellenbosch, Cape Province.
1905. Petersen, Carl Olief, P.O. Box 4938, Johannesburg.
1917. Petersen, Henry Alfred, P.O. Box 3696, Johannesburg.
1917. Petrie, Alexander, M.A., Professor of Classics, Natal University College, Maritzburg.
1915. Pettey, Franklin William, B.A., Ph.D., Entomologist, Government School of Agriculture, Elsenburg, Mulder's Vlei, Cape Province.
1904. Pettman, Rev. Charles, 45, Prince Albert Street, Queenstown, Cape Province.
1918. Philip, David R. C., P.O. Box 143, Johannesburg.
1915. Phillips, Edwin Percy, M.A., D.Sc., F.L.S., Division of Botany, P.O. Box 1294, Pretoria.
1912. Pickstone, Harry Ernest Victor, Lekkerwyn, Groot Drakenstein, Cape Province.
1903. Pim, Howard, C.B.E., B.A., F.C.A., P.O. Box 1331, Johannesburg.
1922. Plein, B., P.O. Box 2297, Johannesburg.
1915. Plowman, George Thomas, C.M.G., Administrator, Natal Province, Maritzburg.
1918. Porter, Dr. Annie, D.Sc., F.L.S., South African Institute for Medical Research, P.O. Box 1038, Johannesburg.
1922. Porteous, A. N., P.O. Box 6962, Johannesburg.
1921. Potgieter, T. D., School of Agriculture, Glen, O.F.S.
1905. Potts, George, M.Sc., Ph.D., Professor of Botany, Grey University College, Bloemfontein.
1919. Powell, John, M.Inst.M. & C.E., City Engineer, Town Hall, East London, Cape Province.
1916. Powell, Owen Price, P.O. Box 192, Germiston, Transvaal.
1922. Prates, Dr. M. M., Hospital, Lourenço Marques.
1921. Prescott, G. P., B.A., 35, Mons Road, Bellevue, Johannesburg.
1916. Price, Bernard, O.B.E., M.I.E.E., A.M.I.C.E., A.M.Am.I.E.E., P.O. Box 2671, Johannesburg.

1913. Provay Giuseppe, Chief Electrical Engineer of Harbours and Railways, P.O. Box 1479, Lourenço Marques.
1921. Pullinger, Dr. Beatrice D., South African Institute for Medical Research, P.O. Box 1038, Johannesburg.
1921. Pullinger, Miss I. E., B.Sc., P.O. Box 1176, Johannesburg.
1917. Purchas, Thomas Alfred Rufus, P.O. Box 272, Johannesburg.
1918. Putterill, Victor A., M.A., Division of Botany, Department of Agriculture, Capetown.
1919. Pyper, Adrianus, M.D., L.S.A., 57, Celliers Street, Pretoria.
1917. Pyper, Cornelius, M.D., 69-70, Chudleigh's Buildings, Johannesburg.

1902. Quinan, Kenneth B., C.H., Chemical Engineer, Cape Explosive Works, Somerset West, Cape Province.
1921. Quinton, H., P.O. Box 2755, Johannesburg.
1921. Quirke, F. O., Highfield Terrace, Doornfontein, Johannesburg.

1921. Raphael, R., P.O. Box 356, Johannesburg.
1919. Rattray, George, M.A., D.Sc., F.R.G.S., Principal, Selborne College, East London, Cape Province.
1919. Rayner, Charles Tainton, P.O. Box 113, Goold Street, West Bank, Kingwilliamstown, Cape Province.
1916. Read, Herbert Alfred, F.S.A.A., P.O. Box 1056, Johannesburg.
1916. Reeve, Herbert C., M.A., High School, Krugersdorp, Transvaal.
1902. Reid, Arthur Henry, F.R.I.B.A., F.R.San.I., P.O. Box 120, Capetown.
1914. Reid, Walter, F.R.I.B.A., P.O. Box 746, Johannesburg.
1916. Reunert, Jack, c/o Messrs. Reunert & Lenz, Consolidated Buildings, Johannesburg.
1902. Reunert, Theodore, M.I.C.E., M.I.M.E., P.O. Box 92, Johannesburg.
1907. Reuter, Rev. Fritz L., Medingen, P.O. Duivelskloof, Transvaal.
1903. Reyersbach, Louis J., 29 & 30, Holborn Viaduct, London, E.C.
1913. Reyneke, Rev. Jacobus Cornelius, De Pastorie, Cradock, Cape Province.
1921. Reynolds, Sir F., Uhhlali, Esperanza, Natal.
1916. Reynolds, H., M.I.Mech.E., P.O. Box 92, Johannesburg.
1916. Reynolds-Tait, Joseph St. Guido, P.O. Box 502, Durban, Natal.
1920. Reynolds, Mrs. E., Kloofside, Houghton Estate, Johannesburg.
1916. Rice, Frank Peabody, P.O. Box 930, Johannesburg.
1920. Rishworth, Mrs. V., Grace Dien, Pietersburg, Transvaal.
1903. Ritchie, William, M.A., Professor of Latin, University of Capetown.
1916. Robb, Andrew D., Trades School, Smit Street, Johannesburg.
1921. Robb, A. M., M.A., P.O. Box 4439, Johannesburg.
1902. Roberts, Senator Alexander William, D.Sc., F.R.A.S., F.R.S.E., Lovedale, Cape Province.
1921. Roberts, Austin, P.O. Box 413, Pretoria.
1921. Roberts, David P., P.O. Box 1003, Johannesburg.
1919. Roberts, Hamilton Mills Goldfinch, P.O. Box 95, Downing Street, Kingwilliamstown, Cape Province.
1913. Roberts, Rev. Noel, M.C., The Vicarage, Orchards, Johannesburg.
1919. Robertson, Colin C., M.F., c/o Forest Department, Pretoria.
1906. Robertson, John, P.O. Box 13, Bloemfontein.
1920. Robertson, Miss I. H., P.O. Sinksa, Sidine, George, Cape Prov.
1920. Robertson, J. B., M.A., B.Sc., The University, Johannesburg.
1920. Robinson, Miss A. A., Natal Training College, Maritzburg.
1915. Robinson, Eric Maxwell, Dr. Med. Vet., M.R.C.V.S., P.O. Box 593, Pretoria.
1920. Robinson, Miss L. D., B.A., 18, Bellevue Road, Durban, Natal.
1920. Robson, Miss G. M., B.A., Huguenot College, Wellington, Cape Province.

1902. ROGERS, Arthur William, M.A., Sc.D., F.R.S., Director, Geological Survey, P.O. Box 401, Pretoria.
1915. ROMYN, Mrs. Elizabeth, "Zonnehoek," 157, Troye Street, Pretoria.
1921. RORKE, H. V., Union Corporation, Ltd., P.O. Box 1156, Johannesburg.
1902. ROSE, James Wilmot Andreas, M.I.C.E., Municipal Offices, Stellenbosch, Cape Province.
1905. ROSE, Lieut.-Colonel John George, D.S.O., F.C.S., Government Chemical Laboratory, Capetown.
1921. ROSENSTEIN, A., M.Sc., The University, Johannesburg.
1912. ROSEVEARE, W. N., M.A., Professor of Mathematics, Natal University College, Maritzburg.
1914. Ross John, P.O. Box 636, Kimberley, Cape Province.
1917. ROSS, Professor John Carl, B.A., M.S., Ph.D., Transvaal University College, Pretoria.
1920. ROUSSEAU, Professor I. J., B.A., Rhodes' University College, Grahamstown, Cape Province.
1920. ROUX, Miss M., 256, Scheiding Street, Pretoria.
1902. RUNCIMAN, William, M.L.A., Simonstown, Cape Province.
1922. RUSSELL, Dr. Wm., Mental Hospital, Bloemfontein.
1915. RUTHVEN, Dr. Jane Buchanan Henderson, M.D., L.R.C.P., L.R.C.S., F.R.S.A., P.O. Box 6253, Johannesburg.

1920. SANER, J. G., F.R.C.S., M.Ch., L.R.C.P., 9, Anstey's Buildings, Johannesburg.
1920. SANKEY, Bernard, M.I.E.E., P.O. Box 699, Johannesburg.
1920. SANDGROUND, J., M.Sc., The University, Johannesburg.
1915. SCHLUPP, William Francis, B.Sc., Lecturer in Zoology and Entomology, Government School of Agriculture, P.O. Box 181, Potchefstroom.
1917. SCHOCH, Edward Rengers, M.I.M.M., P.O. Box 2927, Johannesburg.
1902. SCHONLAND, Selmar, M.A., Ph.D., F.L.S., C.M.Z.S., Professor of Botany, Rhodes' University College, Grahamstown, C.P.
1913. SCHOOL OF AGRICULTURE, Cedara, Natal.
1913. SCHOOL OF AGRICULTURE, Elsenburg, Mulder's Vlei, Cape Prov.
1913. SCHOOL OF AGRICULTURE and Experimental Farm, Glen, O.F.S.
1913. SCHOOL OF AGRICULTURE and Experimental Station, Grootfontein, Middelburg, Cape Province.
1913. SCHOOL OF AGRICULTURE and Experimental Farm, Potchefstroom, Transvaal.
1916. SCHREIBER, Oscar Albert Egmont, P.O. Box 396, Maritzburg.
1918. SCHULTZ, Mark, C.E., P.O. Box 19, Breyton, Transvaal.
1920. SCHURMAN, Miss H. E., M.A., Huguenot College, Wellington, Cape Province.
1914. SEARLE, Mrs. Amy H., B.A., Great Brak River, Cape Province.
1919. SELKE, Advocate E. A., M.A., 4, Court Gardens, Maritzburg.
1912. SHAND, Samuel James, Ph.D., D.Sc., F.G.S., Professor of Geology, University of Stellenbosch, Cape Province.
1916. SHERIDAN, Norman, M.D., B.S., Chudleigh's Buildings, Johannesburg.
1916. SHERWELL, Percy W., City Deep Gold Mining Co., Johannesburg.
1916. SHORE, John, P.O. Box 2997, Johannesburg.

1902. SHORES, J. W., C.M.G., M.I.C.E., Rutland, Scottsville, Maritzburg.
1918. SIBBETT, Cecil James, P.O. Box 914, Capetown.
1916. SIEDLE, Otto, P.O. Box 931, Durban, Natal.
1916. SIM, Thomas Robertson, D.Sc., 168, Burger Street, Maritzburg.
1916. SIMON, Frank, M.I.M.E., P.O. Minaar, Transvaal.
1916. SIMPSON, Archibald James Grant, A.M.I.E.E., P.O. Box 239, Capetown.

1917. SKAIFE, Sydney Harold, M.A., M.Sc., Department of Education, Capetown.
1920. SKIBBE, A., B.A., B.Sc., School of Agriculture, Potchefstroom.
1902. SMARTT, Hon. Sir Thomas William, K.C.M.G., L.R.C.S.I., L.Q.C.P.I., M.L.A., Glen Ban, Stellenbosch, Cape Province.
1920. SMIT, B. J., B.A., 840, Arcadia Street, Pretoria.
1916. SMITH, Arthur Herbert, P.O. Box 141, Durban, Natal.
1921. SMITH, Arthur Yuart, P.O. Box 4854, Johannesburg.
1921. SMITH, Arnold, P.O. Box 1207, Johannesburg.
1916. SMITH, Frank Cumming, Grootfontein School of Agriculture, Middelburg, Cape Province
1920. SMITH, G. H., B.Sc., M.I.M.M., P.O. Box 1024, Johannesburg.
1912. SMITH, George William, A.M.I.C.E., 11, Constitution Hill, Port Elizabeth, Cape Province.
1916. SMITH, Hon. C. G., P.O. Box 43, Durban.
1903. SMITH, James, M.A., Strathspey, Tokai Road, Retreat, Cape Province.
1920. SMITH, William, M.B., Ch.B., 381, Commissioner Street, Johannesburg.
1917. SMITH, Johannes Jacobus, B.A., Professor of French and German, University of Stellenbosch, Cape Province.
1905. SMUTS, Lieut.-General Right Hon. Jan Christiaan, K.C., C.H., B.A., LL.D., Prime Minister, P.O. Box 1081, Pretoria.
1914. SMYTH, Right Rev. Bishop William Edmund, M.A., M.B., The Rectory, Woodstock, Cape Province.
1922. SMYTH, T. C., S.A. Railways and Harbours, Johannesburg.
1919. SNAPE, Alfred Ernest, M.Sc., M.I.C.E., F.R.San.I., Professor of Civil Engineering, University, Capetown.
1903. SOLLY, Mrs. Julia F., Knor Hoek, Sir Lowry's Pass, Cape Prov.
1903. SOLOMON, Hon. Justice Sir W. H., High Court of Appeal, Capetown.
1908. SOMERVILLE, Alfred James, M.A., P.O. Box 126, Salisbury, Rhodesia.
1922. SOROMENHO, Dr. L. J. P., Chemical Laboratory, Hospital, Lourenço Marques.
1910. SOUTTER, John Lyall, P.O. Box 403, Pretoria.
1916. SOWTER, Godfrey Dennis, P.O. Box 1020, Johannesburg.
1906. SPENCER, Dr. Henry Alexander, M.R.C.S., L.R.C.P., Middelburg, Transvaal.
1903. SPILHAUS, William, c/o Messrs. W. Spilhaus & Co., Strand Street, Capetown.
1919. SQUIRE-SMITH, Henry, P.O. Box 21, Kingwilliamstown, Cape Province.
1913. STAFFORD, Miss Susan, M.A., Huguenot College, Wellington, Cape Province.
1905. STALLARD, C. F., K.C., P.O. Box 5156, Johannesburg.
1922. STAMMERS, A. Dighton, B.A., The University, Johannesburg.
1921. STANDING, H. F., D.Sc., Thornhill, Hillary, Natal.
1905. STANLEY, George Hardy, A.R.S.M., M.I.M.E., M.I.M.M., F.I.C., Professor of Metallurgy and Assaying, The University, Johannesburg.
1918. STANLEY, Mrs. A. M., P.O. Box 1176, Johannesburg.
1904. STEAD, Arthur, B.Sc., F.C.S., School of Agriculture, Grootfontein, Middelburg, Cape Province.
1908. STEEDMAN, Miss E. C., M.A., c/o Mrs. Summers, Herefordshire Farm, Gwelo, Southern Rhodesia.
1917. STEPHENS, Miss Edith Layard, B.A., F.L.S., University of Capetown.
1920. STEPHENSON, Frank O., P.O. Box 1034, Johannesburg.
1920. STEVENSON, F. O., P.O. Box 1034, Johannesburg.
1903. STEVENS, J. D., P.O. Box 1782, Johannesburg.
1909. STEWART, G. A., P.O. Box 435, Johannesburg.
1920. STIBBE, Professor E. P., M.R.C.S., L.R.C.P., The University, Johannesburg.

1918. STIRLING, Matthew Miller, P.O. Box 246, Germiston, Transvaal.
1920. STOKES, R. S. G., D.S.O., M.C., O.B.E., Hotel Belgrave, Kimberley, Cape Province.
1905. STONEMAN, Miss Bertha, D.Sc., Huguenot College, Wellington, Cape Province.
1921. STOKES, F. A., P.O. Box 2343, Johannesburg.
1917. STOREY, Francis Wylie, B.Sc., St. Andrew's School, Bloemfontein.
1921. STORE, Percy van der Byl, P.O. Box 303, Johannesburg.
1902. STOTT, Clement H., F.G.S., M.S.A., P.O. Box 7, Maritzburg.
1920. STOTT, N. A., C.A., P.O. Box 1152, Johannesburg.
1916. STRAPP, Walter Russell, M.D., 248, Loop Street, Maritzburg
1904. STRUBEN, A. M. A., A.M.I.C.E., P.O. Box 317, Pretoria.
1906. STUCKE, W. H., P.O. Box 2271, Johannesburg
1918. SUTTIE, David P., Logoza, Private Bag, Ginginhlovu, Zululand.
1922. SWANEPOEL, J., Stellenbosch, Cape Province.
1915. SWIERSTRA, Cornelius Jacobus, F.E.S., P.O. Box 413, Pretoria.

1922. TAAFE, E. G. L., P.O. Box 1515, Johannesburg.
1918. TABERER, Henry Melville, B.A., P.O. Box 1251, Johannesburg.
1921. TAIT, James John, P.O. Box 1057, Johannesburg.
1905. TANNAHILL, Thomas Findlay, M.D., C.M., D.P.H., Queenstown, Cape Province.
1918. TANNOCK, John Porter, M.B., C.M., D.P.H., P.O. Box 5315, Johannesburg.
1918. TAPSCOTT, Sidney, B.Sc., "Tipperary," Riverton Road, Cape Province.
1921. TAYLOR, Miss Esther, M.Sc., The University, Johannesburg.
1920. TAYLOR, H. J., P.O. Box 393, Salisbury.
1920. TAYLOR, Miss L. M. L., Girls' Collegiate School, Maritzburg.
1909. TEASDALE, Miss Emma L., Government School, Maraisburg, Transvaal.
1921. TENNANT, E. B. H., P.O. Box 4755, Johannesburg.
1904. THEILER, Sir Arnold, K.C.M.G., D.Sc., Director, Veterinary Research Laboratory, P.O. Box 593, Pretoria.
1920. THODAY, Mrs. M. G., 35, Rosmead Avenue, Gardens, Capetown.
1920. THODAY, Professor D., M.A., University of Capetown.
1903. THOMAS, Walwyn, B.C., M.B., B.A., 2, Greenham Villas, Annandale Street, Capetown.
1914. THOMPSON, Frederick Handel, B.A., Inspector of Schools, P.O. Box 4439, Johannesburg.
1916. THOMPSON, James, 6, Rissik Street, Johannesburg.
1919. THOMSON, A. R., Wankie, Rhodesia.
1913. THOMSON, Samuel, C. A., P.O. Box 228, Johannesburg.
1920. THOMSON, Miss M. R. H., B.A., M.Sc., P.O. Box 994, Pretoria.
1902. THOMSON, Sir William, M.A., B.Sc., LL.D., F.R.S.E., University of South Africa, P.O. Box 392, Pretoria.
1910. THORNTON, Russel William, Principal, Government School of Agriculture, Grootfontein, Middelburg, Cape Province.
1903. TIETZ, Professor Heinrich C. J., M.A., Ph.D., Buona Vista, Burham Road, Observatory Road, Capetown.
1922. TORRANCE, W., School of Agriculture, Grootfontein, Middelburg, Cape Province.
1902. TOWNSEND, Stephen Frank, C.E., Suevic, Southfield Road, Plumstead, Cape Province.
1921. TREASURER (Commissioner of Mines), Nairobi, Kenya Colony.
1919. TRILL, George William Charles, c/o Findlay and Co., Ltd., Parliament Street, Capetown.
1910. TROLLIP, W. L., Office of the Hon. Administrator of the Cape Province, Capetown.
1906. TROUP, James Macdonald, M.B., Ch.B., L.S.A., 230, Esselen Street, Sunnyside, Pretoria.

1916. TRUBSHAW, Henry Arthur, "Dunrobin," Empire Road, Parktown, Johannesburg.
1922. TUCKER, R. W. E., M.A., Entomological Experimental Station, Rosebank, Capetown.
1903. TUCKER, William Kidger, C.M.G., P.O. Box 9, Johannesburg.
1922. TUCKER, G. K., P.O. Box 957, Johannesburg.
1916. TURNER, F. E., P.O. Box 407, Johannesburg.
1906. TYERS, F. G., M.A., Boys' High School, Potchefstroom.

1916. UDWIN, M., Rand Water Board, Johannesburg.
1917. UNION Department of Education, Pretoria.
1917. UNION Observatory, c/o Union Astronomer, Johannesburg.
1920. URQUHART, Rev. Father, Kerk Street, Johannesburg.

1915. VAN DER BYL, Professor Paul Andries, M.A., D.Sc., F.L.S., University of Stellenbosch, Cape Province.
1920. VAN DER KOPPEL, Miss L. H., Huguenot University College, Wellington, Cape Province.
1909. VAN DER MERWE, C.P., Government Entomologist, Currie Road, Durban, Natal.
1920. VAN DER MERWE, H., Smithfield, Potchefstroom.
1917. VAN DER RIET, W. J., Government School, Bramley, Johannesburg.
1910. VAN DER RIET, Berthault de St. Jean, M.A., Ph.D., Professor of Chemistry, University of Stellenbosch, Cape Province.
1904. VAN DER STEER, W. C., P.O. Box 27, Capetown.
1922. VAN HOOPEN, Dr. E. C. N., National Museum, Bloemfontein.
1922. VAN NIEKERK, D. J., Paarl, Cape Province.
1917. VAN NIEKERK, John, M.B., C.M., P.O. Box 473, Johannesburg.
1918. VAN NIEKERK, Sebastian Valentyn, M.D., B.S., P.O. Box 1564, Johannesburg.
1918. VAN WYK, Daniel Jacobus Roselt, B.A., Division of Chemistry, Department of Agriculture, Pretoria.
1918. VARDER, Richard William, M.A., Professor of Physics, Rhodes' University College, Grahamstown, Cape Province.
1922. VELLACOTT, P. N., M.B., F.R.C.S., 9, de Villiers Street, Bloemfontein.
1920. VILJOEN, Dr. W. J., Superintendent of Education, Queen Victoria Street, Capetown.
1919. VOGTS, Ferdinand Carl Louis, P.O. Box 6, Kingwilliamstown, Cape Province.
1903. VON OPPEL, Otto Karl Adolf, Department of Lands, Pretoria.

1916. WADE, Walter B., P.O. Box 932, Durban, Natal.
1912. WAGER, Horace Athelstan, A.R.C.S., Professor of Botany, Transvaal University College, Pretoria.
1916. WAGNER, Percy Albert, Ing.D., B.Sc., P.O. Box 846, Pretoria.
1919. WAKEFIELD, Samuel Thomas, B.A., 62a, Union Street, East London, Cape Province.
1912. WALKER, James, M.R.C.V.S., P.O. Box 323, Nairobi, British East Africa.
1920. WALLACE, Richard C., A.M.I.C.E., Chief Civil Engineer's Office, S.A. Railways, Johannesburg.
1902. WALSH, Albert, P.O. Box 39, Capetown.
1916. WALTON, Arthur John, P.O. Box 102, Crown Mines, Johannesburg.
1921. WANGER, Rev. W., Gaimersheim, Oberbayern, Germany.
1920. WARD, H. St. John, Brebner School, Exton Street, Bloemfontein.
1922. WARE, Rev. G. Hibbert, St. Aidan's Mission, Cross Street, Durban, Natal.
1922. WARE, Mrs. Hibbert, St. Aidan's Mission, Cross Street, Durban, Natal.

1914. Wark, Rev. David, M.A., D.D., The Manse, Woodley Street, Kimberley, Cape Province.
1907. Warren, Ernest, D.Sc., Professor of Zoology, Natal University College, Maritzburg, and Director of Natal Museum.
1916. Waterhouse, Osborn, M.A., Professor of English and Philosophy, Natal University College, Maritzburg
1920. Watermeyer, Professor G. A., B.A., A.R.S.M., The University, Johannesburg.
1902. Watkins, Arnold Hirst, M.D., M.R.C.S., M.L.A., Ingke Nook, Kimberley, Cape Province.
1906. Watkins-Pitchford, Wilfred, M.D., F.R.C.S., D.P.H., Director, South African Institute for Medical Research, P.O. Box 1038. Johannesburg.
1914. Watson, Thomas Hunter, P.O. Box 1400, Capetown.
1921. Watson, R. W., Borough Engineer's Office, Durban, Natal.
1906. Watt, Dugald Campbell, M.D., 131, Pietermaritz Street, Maritzburg.
1922. Watts, J. N., Jeppe High School, Johannesburg.
1912. Way, William Archer, M.A., Grey Institute, Port Elizabeth, Cape Province.
1918. Weatherby, Ellis Wynne, P.O. Box 40, Kimberley, Cape Prov.
1914. Webb, George Arthur, A.I.E.E., M.S.A., P.O. Box 692, Port Elizabeth, Cape Province.
1916. Webber, Walter Solomon, B.A., P.O. Box 1088, Johannesburg.
1921. Webster, D. T., P.O. Box 7034, Johannesburg.
1920. Weeks, George, Joubert Park, Johannesburg.
1919. Weidner, Chas., Goodhouse Farm, P.O. Steinkopp, Cape Prov.
1911. Welch, Rev. Sidney Read, B.A., D.D., Ph.D., St. Mary's, Cathedral, Bouquet Street, Capetown.
1921. Wellington, J. H., B.A., The University, Johannesburg.
1919. Wessels, D. H., M.B., P.O. Box 1319, Capetown.
1903. Wessels, Hon. Justice Sir J. W., Kt., B.A., LL.B., Pretoria.
1916. Wessels, Johannes Jacobus, M.E., Afrikander Mine, Klerksdorp, Transvaal.
1910. Wertheim, Louis, c/o New Club, Johannesburg
1902. White, Miss Frances Margaret, "Arkleside," Eden Road, Claremont, Cape Province.
1902. White, Miss Henrietta Mary, B.A., "Arkleside," Eden Road, Claremont, Cape Province.
1920. White, Senator, I.A., P.O. Box 188, Germiston, Transvaal.
1919. Whitehouse, J., P.O. Box 1064, Johannesburg.
1902. White-Cooper, W., M.A., F.R.I.B.A., P.O. Box 11, Cradock, Cape Province.
1909. Whitwort:, Walter S., Koffyfontein Diamond Mines, O.F.S.
1904. Wilhelm, A. R. A., M.B., C.M., Barkly East, Cape Province.
1904. Wilkinson, Professor J. A., M.A., F.C.S., Department of Chemistry, The University, Johannesburg.
1902. Williams, Alpheus Fuller, B.Sc., Mining Engineer, De Beers Consolidated Mines, Ltd., P.O. Box 616, Kimberley, C.P.
1916. Williams, Charles Herbert, P.O. Box 2155, Johannesburg.
1912. Williams, Cornelius O., B.Sc., A.R.C.S., Government School of Agriculture, Cedara, Natal.
1920. Wienand, C. F., Commercial Exchange Buildings, Main Street, Johannesburg.
1920. Williams, H. J., Main Street, Plumstead, Cape Province.
1920. Williams, Mrs. A. M., Main Street, Plumstead, Cape Province.
1902. Williams, Professor D., B.Sc., Rhodes' University College, Grahamstown, Cape Province.
1902. Williams, Gardner F., M.A., LL.D., 2201 R. Street, N.W., Washington, D.C., U.S.A.
1922. Williamson, Mrs. E. G., c/o The University, Johannesburg.
1920. Williamson, Miss M., 350, Mare Street, Pretoria.
1922. Williamson, Professor O. K., M.A., M.D., F.R.C.P., The University, Johannesburg.

1918. Williamson, Sidney, Ph.D., F.I.C., F.C.S., Cooper Technical Bureau, Bloomsbury, London, W.C.2.
1903. Wilman, Miss M., McGregor Memorial Museum, Kimberley, Cape Province.
1903. Wilson, Arthur Marius, M.D., B.S., L.R.C.P., M.R.C.S., Jesmond House, Hof Street, Capetown.
1916. Wilson, Charles Edmund, A.M.I.E.E., P.O. Box 930, Johannesburg.
1917. Wilson, James Hugh Elwes, P.O. Box 4303, Johannesburg.
1920. Wilson, N. H., Native Department, Bulawayo, Rhodesia.
1903. Winterton, Albert Wyle, F.C.S., Lemoenfontein, near Beaufort West, Cape Province.
1906. Wood, H. E., M.Sc., F.R.Met.S., Union Observatory, Johannesburg.
1905. Wood, James, M.A., P.O. Box 2, Kingwilliamstown, Cape Prov.
1920. Wood, W. S., Country Club, Auckland Park, Johannesburg.
1919. Woodrow, Edwin James Carr, J.P., Town Clerk and Treasurer, Kingwilliamstown, Cape Province.
1916. Woods, Mrs. Sarah, Ladies' Club, Y.M.C.A. Buildings, Maritzburg.
1919. Wormald, William Henry, F.R.H.S., Town Office, East London.
1921. Worsfold, Sidney F., P.O. Box 6556, Johannesburg.
1916. Wright, Miss Kathleen Margaret, B.Sc., Normal College, Pretoria.
1915. Wyatt, Stanley, M.Sc., M.Ed., Normal College, P.O. Box 855, Pretoria.
1916. Wylie, James Scott, K.C., Scotswood, Ridge Road, Durban, Natal.

1921. Young, James, 68, Yeo Street, Yeoville.
1920. Young, J. J., M.A., 107, Persimmon Street, Malvern, Johannesburg.
1904. Young, Professor R. B., M.A., D.Sc., The University, Johannesburg.
1920. Young, W. H. W., Lieut.-Colonel, Maritzburg, Natal.

1922. Zweerts, Francois, Grey University College, Bloemfontein

DOUBLE NUMBER.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE:

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

1921.

DURBAN.

OFFICERS, 1921-1922:

PRESIDENT.

A. W. Rogers, Sc.D., F.R.S.

VICE-PRESIDENTS.

Prof. A. Brown, M.A., B.Sc.
Prof. R. B. Denison, D.Sc., Ph.D. E. Farrar.
Prof. T. M. Forsyth, M.A., D.Phil.

HON. GENERAL SECRETARIES.

H. E. Wood, M.Sc., F.R.A.S., Union Observatory, Johannesburg.
C. F. Juritz, M.A., D.Sc., F.I.C., Division of Chemistry, Dept. of Agriculture, Capetown.

HON. GENERAL TREASURER.

Jas. Gray, F.I.C., Johannesburg.

HON. LIBRARIAN.

Annie Porter, D.Sc., South African Institute for Medical Research, Johannesburg.

ASSISTANT GENERAL SECRETARY.

H. A. G. Jeffreys, O.B.E., Box 6894, Johannesburg. Telegraphic Address: "Science."

HON. EDITOR OF JOURNAL.

Prof. H. B. Fantham, M.A., D.Sc., The University, Johannesburg.

VOL. XVIII. DECEMBER, 1921. Nos. 1 and 2.

JOHANNESBURG.
PUBLISHED BY THE ASSOCIATION.

1921.

[Price 15s.

The price of this Journal to the general public is as marked on the front page. Every member of the Association is supplied with one copy free, and may obtain extra copies at half-price. Applications for copies should be addressed to the Assistant General Secretary, P.O. Box 6894, Johannesburg.

CORRESPONDENCE.—All communications other than those relating to the Journal **should be addressed to the Assistant Secretary, P.O. Box 6894, Johannesburg.** (Telegraphic address: "Science, Johannesburg.")

Communications for the Editor should be addressed to P.O. Box 1176, Johannesburg.

MANUSCRIPTS for publication should be typewritten.

ILLUSTRATIONS (other than photographs) accompanying papers intended for publication in the Journal must be supplied by the authors, carefully drawn about **twice the size** of the finished block, on smooth white Bristol board, in **Indian ink,** so as to admit of the blocks being prepared directly from the drawings. Any lettering on these drawings should be of such a size that it will be clearly legible when reduced.

REPRINTS.—Authors desiring to have reprints of their papers, read at the Annual Meeting of the Association, are requested to notify the Editor as soon as possible as to the number required, or, at latest, when returning their proofs.

LOOSE COVER CASES.—Cases uniform with the covers of previous volumes may be obtained for binding on application to the Assistant General Secretary, at a cost of 4s. per case post free.

BINDING VOLUME XVII.—The publication of Vol. xvii of the Journal, comprising the papers read at the Bulawayo (1920) meeting, is now completed. Members desiring to have their separate numbers of this volume bound should forward them to the Assistant General Secretary, and inform him of their wishes, when the orders will be given to the binders. The cost of the cover and binding will be 12s. 6d. post free.

SUBSCRIPTIONS.—Subscriptions of £1 10s. for the year ending 30th June, 1922, are now due. Members are requested to be so kind as to remit the amount as soon as possible to the Assistant General Secretary, P.O. Box 6894, Johannesburg. Unless members pay the amount due at an early date, great inconvenience and unnecessary expense may be caused, as it is very difficult to determine what number of copies of the Journal will be required. The Council therefore appeals to every member for support and co-operation, and asks that outstanding subscriptions be paid without delay. **The Journal will be sent only to those whose arrear subscriptions are paid.**

Cheques, etc., should be crossed and made payable to the **Association, not to the Secretaries or Treasurer individually.** Sixpence should be added to country cheques for exchange.

HEADQUARTERS.—Attention is called to the change of Headquarters decided on at the Kingwilliamstown (1919) session. The office address of the Association now is "P.O. Box 6894, Johannesburg"; the telegraphic address is "Science, Johannesburg," and the telephone number "1404, Johannesburg."

Johannesburg, 31st December, 1921.

PUBLICATIONS OF THE ASSOCIATION.

Copies of the following bound volumes (royal 8vo) of the Association's Reports may be obtained from the Assistant General Secretary (P.O. Box 6894, Johannesburg) at the prices indicated:—

Vol. I.—Cape Town, 1903. 556 pp. Price 10s. net; to Members, 5s.
Vol. II.—Johannesburg, 1904. 598 pp. Price, 10s. net; to Members, 5s.
Vol. III.—Kimberley, 1906. 696 pp. Price, 20s. net; to Members, 10s.
Vol. IV.—Natal, 1907. 230 pp. Price, 10s. net; to Members, 5s.
Vol. V.—Grahamstown, 1908. 436 pp. (Out of print).
Vol. VI.—Bloemfontein, 1909. 542 pp. (Out of print.)
Vol. VII.—Cape Town, 1910. 488 pp. Price, 20s. net; to Members, 10s.
Vol. VIII.—Bulawayo, 1911. 472 pp. Price, 20s. net; to Members, 10s.
Vol. IX.—Port Elizabeth, 1912. 460 pp. Price, 20s. net; to Members, 10s.
Vol. X.—Lourenço Marques, 1913. 533 pp. Price, 20s. net; to Members, 10s.
Vol. XI.—Kimberley, 1914. 484 pp. Price, 20s. net; to Members, 10s.
Vol. XII.—Pretoria, 1915. 806 pp. Price, 30s. net; to Members, 15s.
Vol. XIII.—Maritzburg, 1916. 714 pp. Price, 30s. net; to Members, 15s.
Vol. XIV.—Stellenbosch, 1917. 646 pp. Price, 30s. net; to Members, 15s.
Vol. XV.—Johannesburg, 1918. 874 pp. Price, 35s. net; to Members, 15s.
Vol. XVI.—Kingwilliamstown, 1919. 536 pp. Price, 32s. net; to Members, 16s.
Vol. XVII.—Bulawayo, 1920. 400 pp. Price, 32s. net; to Members, 16s.

One shilling should be added to the cost of each of the above volumes for postage.

The Association has also on hand a few bound copies of the Report of the Meeting of the British Association in South Africa in 1905; price, 24s.; to Members, 10s. 6d.

"Science in South Africa."—A few copies of this valuable handbook, which was specially prepared for the Members of the British Asociation visiting South Africa in 1905, are for sale; price, 21s. (or 22s. post free).

INFORMATION REGARDING THE ASSOCIATION.

Objects.—The objects of the Association are: To give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of Societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

Ordinary Members.—Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay *without intermission* their Annual Subscription. The Annual Subscription for Ordinary Members is One Pound Ten Shillings, payable, first, at election, and thereafter on the 1st of July of each year.

Life Members.—Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association. Every Life Member shall pay, on admission as such, the sum of Fifteen Pounds. An Ordinary Member may at any time become a Life Member by one payment of Fifteen Pounds in lieu of future annual subscriptions, or, after ten years' continuous membership, by one payment of Seven Pounds Ten Shillings.

Associates.—Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association. The subscription for Associates for a session is One Pound.

Ladies.—Ladies may become Members or Associates of the Association.

CONTENTS.

Natal Witness, Ltd., Printers, Maritzburg.

DOUBLE NUMBER.

THE

SOUTH AFRICAN JOURNAL OF SCIENCE:

COMPRISING THE REPORT OF THE

SOUTH AFRICAN ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE

1921.
DURBAN.

OFFICERS, 1921-1922:

VOL. XVIII. JUNE, 1922. Nos. 3 and 4.

JOHANNESBURG.
PUBLISHED BY THE ASSOCIATION.

1922.

[Price 17s.

The price of this Journal to the general public is as marked on the front page. Every member of the Association is supplied with one copy free, and may obtain extra copies at half-price. Applications for copies should be addressed to the Assistant General Secretary, P.O. Box 6894, Johannesburg.

CORRESPONDENCE.—All communications other than those relating to the Journal **should be addressed to the Assistant Secretary, P.O. Box 6394,** Johannesburg. (Telegraphic address: "Science, Johannesburg.")

Communications for the Editor should be addressed to P.O. Box 1176, Johannesburg.

PAPERS for publication should be typewritten.

ILLUSTRATIONS (other than photographs) accompanying papers intended for publication in the Journal must be supplied by the authors, carefully drawn about **twice the size** of the finished block, on smooth white Bristol board, in **Indian ink,** so as to admit of the blocks being prepared directly from the drawings. Any lettering on these drawings should be of such a size that it will be clearly legible when reduced.

REPRINTS.—Authors desiring to have reprints of their papers, read at the Annual Meeting of the Association, are requested to notify the Editor as soon as possible as to the number required, or, at latest, when returning their proofs.

LOOSE COVER CASES.—Cases uniform with the covers of previous volumes may be obtained for binding recent Reports on application to the Assistant General Secretary, at a cost of 4s. per case post free.

BINDING VOLUME XVII.—The publication of Vol. xvii of the Journal, comprising the papers read at the Bulawayo (1920) meeting, is completed. Members desiring to have their separate numbers of this volume bound should forward them to the Assistant General Secretary, and inform him of their wishes, when the orders will be given to the binders. The cost of the cover and binding will be 12s. 6d. post free.

VOLUME XVIII., comprising the papers read at the Durban (1921) meeting, is completed in this double number. The volume can be bound for 9s. post free. Arrangements should be made with the Assistant General Secretary, as above.

SUBSCRIPTIONS.—Subscriptions of £1 10s. for the year ending 30th June, 1922, are now due. Members are requested to be so kind as to remit the amount as soon as possible to the Assistant General Secretary, P.O. Box 6894, Johannesburg. Unless members pay the amount due at an early date, great inconvenience and unnecessary expense may be caused, as it is very difficult to determine what number of copies of the Journal will be required. The Council therefore appeals to every member for support and co-operation, and asks that outstanding subscriptions be paid without delay. **The Journal will be sent only to those whose arrear subscriptions are paid.**

Cheques, etc., should be crossed and made payable to the **Association, not to the Secretaries or Treasurer individually.** Sixpence should be added to country cheques for exchange.

HEADQUARTERS.—The office address of the Association now is "P.O. Box 6894, Johannesburg"; the telegraphic address is "Science, Johannesburg," and the telephone number "1404, Johannesburg."

Johannesburg, 30th June, 1922.

PUBLICATIONS OF THE ASSOCIATION.

Copies of the following bound volumes (royal 8vo) of the Association's Reports may be obtained from the Assistant General Secretary (P.O. Box 6894, Johannesburg) at the prices indicated:—

Vol. I.—Cape Town, 1903. 556 pp. Price 10s. net; to Members, 5s.
Vol. II.—Johannesburg, 1904. 598 pp. Price, 10s. net; to Members, 5s.
Vol. III.—Kimberley, 1906. 696 pp. Price, 20s. net; to Members, 10s.
Vol. IV.—Natal, 1907. 230 pp. Price, 10s. net; to Members, 5s.
Vol. V.—Grahamstown, 1908. 436 pp. (Out of print).
Vol. VI.—Bloemfontein, 1909. 542 pp. (Out of print.)
Vol. VII.—Cape Town, 1910. 488 pp. Price, 20s. net; to Members, 10s.
Vol. VIII.—Bulawayo, 1911. 472 pp. Price, 20s. net; to Members, 10s.
Vol. IX.—Port Elizabeth, 1912. 460 pp. Price, 20s. net; to Members, 10s.
Vol. X.—Lourenço Marques, 1913. 533 pp. Price, 20s. net; to Members, 10s.
Vol. XI.—Kimberley, 1914. 484 pp. Price, 20s. net; to Members, 10s.
Vol. XII.—Pretoria, 1915. 806 pp. Price, 30s. net; to Members, 15s.
Vol. XIII.—Maritzburg, 1916. 714 pp. Price, 30s. net; to Members, 15s.
Vol. XIV.—Stellenbosch, 1917. 646 pp. Price, 30s. net; to Members, 15s.
Vol. XV.—Johannesburg, 1918 874 pp. Price, 35s. net; to Members, 15s.
Vol. XVI.—Kingwilliamstown, 1919. 536 pp. Price, 32s. net; to Members, 16s.
Vol. XVII.—Bulawayo, 1920. 400 pp. Price, 32s. net; to Members, 16s.
Vol. XVIII.—Durban, 1921. 559 pp. Price 32s. net; to Members, 16s.

One shilling should be added to the cost of each of the above volumes for postage.

The Association has also on hand a few bound copies of the Report of the Meeting of the British Association in South Africa in 1905; price, 24s.; to Members, 10s. 6d.

"Science in South Africa."—A few copies of this valuable handbook, which was specially prepared for the Members of the British Asociation visiting South Africa in 1905, are for sale; price, 21s. (or 22s. post free).

INFORMATION REGARDING THE ASSOCIATION.

Objects.—The objects of the Association are: To give a stronger impulse and a more systematic direction to scientific inquiry; to promote the intercourse of Societies and individuals interested in Science in different parts of South Africa; to obtain a more general attention to the objects of pure and applied Science, and the removal of any disadvantages of a public kind which may impede its progress.

Ordinary Members.—Ordinary Members shall be eligible for all offices of the Association, and shall receive *gratuitously* all ordinary publications issued by the Association during the year of their admission, and during the years in which they continue to pay *without intermission* their Annual Subscription. The Annual Subscription for Ordinary Members is One Pound Ten Shillings, payable, first, at election, and thereafter on the 1st of July of each year.

Life Members.—Life Members shall be eligible for all offices of the Association, and shall receive gratuitously all ordinary publications issued by the Association. Every Life Member shall pay, on admission as such, the sum of Fifteen Pounds An Ordinary Member may at any time become a Life Member by one payment of Fifteen Pounds in lieu of future annual subscriptions, or, after ten years' continuous membership, by one payment of Seven Pounds Ten Shillings.

Associates.—Associates are eligible to serve on the Reception Committee, but are not eligible to hold any other office, and they are not entitled to receive gratuitously the publications of the Association. The subscription for Associates for a session is One Pound.

Ladies.—Ladies may become Members or Associates of the Association.

CONTENTS.

PAPERS READ—*continued*:—

NATAL WITNESS, LTD., MARITZBURG.